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STATISTICS OF COMPOSITAE IN RELATION TO THE FLORA OF CHINA *

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III. A COMPARISON OF THE COMPOSITAE OF CHINA WITH THOSE OF NEIGHBORING COUNTRIES

The nature of the Compositae in the flora of China can be understood better and its significance more fully realized by a comparison of its components with those of its neighboring countries, namely, Korea, Japan, Indo-China, India, Central Asia (Pamir) and Siberia. The numbers of species in genera common to those areas are given in TABLE III.

TABLE III. **A comparison of the genera of Compositae common to China and its neighboring countries**

TRIBES & GENERA	CHINA	KOREA	JAPAN	INDO-CHINA	INDIA	PAMIR	SIBERIA
Vernonieae							
Vernonia	34	—	1	29	45	—	—
Ethulia	1	—	—	1	1	—	—
Elephantopus	2	—	—	3	1	—	—
Camchaya	1	—	—	1	—	—	—
Eupatorieae							
Adenostemma	2	—	1	1	1	—	—
Ageratum	2	—	—	1	1	—	—
Eupatorium	17	3	13	6	2	—	—
Mikania	3	—	—	1	1	—	—
Astereae							
Solidago	5	—	7	1	1	—	1
Dichrocephala	3	—	1	2	4	—	—
Cyathocline	1	—	—	1	2	—	—
Lagenophora	1	—	1	1	—	—	—
Grangea	2	—	—	1	1	—	—
Rhynchospermum	1	1	1	1	1	—	—
Myriactis	5	—	1	1	3	—	—

* Continued from Volume XXXIX, p. 378.

TABLE III. (*Continued*)

Tribes & Genera	China	Korea	Japan	Indo-China	India	Pamir	Siberia
Asteromoea (*Kalimeris* or *Boltonia*)	10	3	5	1	1	—	—
Heteropappus	5	2	6	—	—	—	—
Aster	137	9	35	1	14	2	9
Galatella	7	—	—	—	—	—	5
Erigeron	25	1	4	3	7	3	13
Microglossa	3	—	—	1	3	—	—
Conyza	9	—	1	3	8	—	—
Thespis	1	—	—	—	1	—	—
Inuleae							
Blumea	30	—	—	31	35	—	—
Blumeopsis	1	—	—	1	—	—	—
Laggera	2	—	—	3	4	—	—
Pluchea	3	—	—	4	7	—	—
Epaltes (*Poilania*)	2	—	—	1	2	—	—
Sphaeranthus	3	—	—	2	4	—	—
Pterocaulon	1	—	—	3	1	—	—
Filago	(?)	—	—	—	2	—	2
Leontopodium	57	3	6	1	1	1	2
Anaphalis	51	1	5	3	27	—	—
Antennaria	2	—	1	—	—	—	2
Phagnalon	(?)	—	—	—	1	—	—
Gnaphalium	20	4	3	3	7	—	4
Helichrysum	2	—	—	—	2	—	1
Inula	28	3	6	5	20	1	7
Vicoa	2	—	—	1	3	—	—
Pulicaria	4	—	—	1	10	—	1
Carpesium	18	5	10	2	3	—	—
Adenocaulon	2	1	1	—	1	—	—
Heliantheae							
Xanthium	2	1	1	1	1	—	2
Parthenium	1	—	—	1	—	—	—
Siegesbeckia	4	3	3	1	1	—	—
Eclipta	1	1	1	1	1	—	—
Enhydra	1	—	—	1	1	—	—
Blainvillea	1	—	—	1	1	—	—
Wedelia	5	1	1	4	4	—	—
Spilanthes	2	—	1	1	1	—	—
Synedrella	1	—	1	1	1	—	—
Glossogyne	1	—	1	3	1	—	—
Bidens	6	6	9	2	3	—	3
Cosmos	1	—	—	1	—	—	—
Galinsoga	1	—	—	—	1	—	—
Tridax	1	—	—	1	1	—	—
Helenieae							
Tagetes	2	—	—	2	—	—	—

TABLE III. (*Continued*)

Tribes & Genera	China	Korea	Japan	Indo-China	India	Pamir	Siberia
Anthemideae							
Anthemis	4	—	—	—	—	—	1
Achillea	10	4	8	1	1	1	10
Matricaria	4	2	2	—	2	—	6
Allardia	2	—	—	—	5	1	2
Chrysanthemum	73	10	30	2	4	7	3
Pyrethrum	5	—	—	—	—	2	15
Brachanthemum	5	—	—	—	—	—	2
Centipeda	1	1	1	1	1	—	—
Crossostephium	1	—	1	1	—	—	—
Artemisia	156	37	40	4	27	20	58
Senecioneae							
Tussilago	1	—	—	—	1	—	1
Petasites	9	2	2	—	—	—	1
Doronicum	3	—	—	—	3	—	4
Nardosmia	(?)	—	—	—	—	—	4
Gynura	16	—	—	—	7	—	—
Emilia	3	—	1	4	5	—	—
Cacalia	60	7	25	—	—	—	1
Arnica	1	—	4	—	—	—	1
Syneilesis	4	2	2	—	—	—	—
Senecio	160	10	13	9	63	3	22
Ligularia	103	7	10	—	—	1	5
Farfugium	1	1	3	—	—	—	—
Cremanthodium	47	—	—	—	7	—	—
Cynareae							
Echinops	11	—	1	—	3	1	7
Atractylis	8	—	1	—	—	—	—
Arctium	2	—	1	—	1	—	2
Cousinia	2	—	—	—	5	5	1
Carduus	11	1	1	—	2	—	3
Cirsium	59	7	77	3	8	1	13
Cephalonoplos	3	—	1	—	—	—	—
Hemistepta	1	1	1	1	—	—	—
Saussurea	270	31	53	3	39	7	25
Jurinea	18	—	—	—	3	1	4
Tricholepis	2	—	—	1	10	—	—
Serratula	19	—	1	—	1	1	8
Centaurea	7	—	—	—	6	1	14
Carthamus	1	—	—	—	3	—	—
Mutisieae							
Pertya	10	—	2	1	—	—	—
Leucomeris	1	—	—	2	2	—	—
Ainsliaea	47	3	10	—	4	—	—
Gerbera	10	—	—	—	5	—	1
Cichorieae							
Cichorium	2	—	—	—	1	—	1

TABLE III. (*Continued*)

Tribes & Genera	China	Korea	Japan	Indo-China	India	Pamir	Siberia
Lapsana	3	—	—	—	1	—	1
Koelpinia	1	—	—	—	1	1	1
Hypochoeris	3	1	1	—	1	—	—
Tragopogon	10	—	—	—	3	4	10
Scorzonera	18	2	2	—	3	1	11
Picris	8	1	5	1	1	—	2
Taraxacum	57	2	37	—	2	2	22
Chondrilla	3	—	—	—	2	—	11
Sonchus	10	1	2	2	4	—	5
Launaea	4	—	—	2	7	—	—
Lactuca	57	4	6	9	22	1	7
Cicerbita	7	—	—	—	—	—	2
Prenanthes	19	—	2	—	6	—	—
Crepis	31	—	2	6	14	3	14
Youngia	30	6	6	—	—	—	—
Ixeris	14	6	14	—	—	—	—
Crepidiastrum	2	2	6	—	—	—	—
Hololeion	1	—	2	—	—	—	—
Hieracium	14	—	3	—	5	—	26

1. China, Korea and Japan

The close floristic affinity between Korea, Japan and China is well known, and for this reason plant geographers usually group the three countries in one phytogeographical province, the Eastern Asiatic Region. The Compositae of these countries confirm this relationship. Kitamura, in his monographic work *Compositae Japonicae*, and Hara, in his *Enumeratio Spermatophytarum Japonicarum*, both include Korea as well as Japan. The figures given in Table III for these countries are abstracted from these publications. It illustrates several interesting features which help us to understand the flora of China and eastern Asia.

(1) As indicated by the number of species in the genera which they have in common, China has the more complex Composite flora. China and Japan have 69 genera in common and in these there are a total of 1751 species in China and 514 species in Japan. The species/genus ratio for China is 25, and for Japan 7.4. There are 44 genera common to China and Korea and in these China has 1473 species and Korea has 203 species. The species/genus ratio is 35.9 for China and 4.6 for Korea. It is interesting to note that the differences of species/genus ratio are due chiefly to the large genera like *Vernonia*, *Aster*, *Leontopodium*, *Anaphalis*, *Senecio*, *Ligularia*, *Echinops*, *Saussurea*, *Prenanthes* and *Crepis*. Many small genera which may be regarded as adventives to the flora of China have the same, or nearly the same, number of species in China, Korea and Japan. *Solidago*, *Xanthium*, *Siegesbeckia*, *Eclipta*, *Centipeda*, *Hemistepta*, *Hypochoeris* and *Lapsana* are only a few examples.

(2) Thirty-one of the thirty-seven large genera of Chinese Compositae occur also in Japan. Twenty-five of these are also found in Korea. Numerous species of these large genera are common to all three countries. For example, *Anaphalis sinica* Hance, *Artemisia annua* Linn., *A. borealis* Pallas, *A. campestris* Linn., *A. japonica* Thunb., *Aster fastigiatus* Fischer, *A. indicus* Linn., *A. scaber* Thunb., *Carpesium abrotanoides* Linn., *Chrysanthemum indicum* Linn., *Cirsium pendulum* Fischer, *Gnaphalium affine* D. Don, *Lactuca sibirica* (Linn.) Benth. are only a few of them. In a way, Korea and Japan are merely additional areas to the continuous range of the large Chinese genera or of the widespread species. As observed by Kitamura, many of these genera extend from China to Japan through Korea and, in fact, this is an important route of plant migration between China and Japan.

(3) Geographically Japan is farther from China than is Korea but floristically there are over one-third more Composite genera which China shares with Japan than with Korea. This is probably due to the small size of Korea and the corresponding limitations in the climatic and edaphic factors that support a more varied vegetation. It is worthy of note that the genera which are common to China and Japan but absent from Korea are pantropical taxa (*Elephantopus*, *Adenostemma* and *Emilia*), tropical Asiatic or African elements (*Dichrocephala* and *Crossostephium*), Australian elements (*Lagenophora*), and Sino-Japanese elements with the range extending from the eastern Himalayan region to Japan but not reaching Korea (*Myriactis* and *Pertya*). The last named genera are especially interesting because they illustrate some southern routes of plant migration between China and Japan. These routes, as illustrated by *Pertya*, are evidently from eastern China, especially through Chekiang or Taiwan to Japan.

(4) It is interesting to consider the genera of Chinese Compositae that are absent from Korea and Japan. Among the large ones there are *Blumea*, *Gynura*, *Cremanthodium*, *Jurinea*, *Gerbera* and *Tragopogon*. Among the small ones, with the exclusion of the 34 which are Chinese endemics, there are still 38 that occur in China but not in Korea or Japan. These are (a) pantropical genera (*Mikania*, *Grangea*, *Pluchea*, *Epaltes*, *Pulicaria*), (b) tropical Asiatic or African genera (*Ethulia*, *Anisopappus*, *Sphaeranthus*), (c) the Australian genus, *Pterocaulon*, (d) American genera (*Acanthospermum*, *Tridax*, *Sanvitalia*), and (e) European-African-Central Asiatic genera (*Allardia*, *Centaurea*, *Cousinia*, *Filago*, *Tragopogon*). Species of groups (a–d) occur only in the tropical and subtropical areas of China (Taiwan, Hainan, Kwangtung, and Yunnan) while species of group (e) occur chiefly in Sinkiang and Tibet.

(5) It is interesting to point out the genera of Compositae that are represented better in Japan than in China or are absent from China. There are five genera which are common to China and Japan, but better represented in Japan. These are *Solidago*, *Heteropappus*, *Bidens*, *Cirsium*, and *Crepidiastrum*. There are 11 genera represented in the flora of Japan but absent from China. These are *Arnica, Dendrocacalia, Diaspanthus, Heterokalimeris, Ixyoungia, Macroclinidium, Macropertya, Miricacalia, Paraixeris*

and *Senecillicacalia.* Ten out of these 11 genera are segregates from Chinese groups (*Youngia, Ainsliaea, Pertya, Senecio* and *Cacalia*). *Arnica* is an American genus which, together with *Solidago,* another American genus which is better represented in Japan than in China, may be taken as an indication that in certain respects the Japanese flora contains more North American elements than the flora of China.

2. China and Indo-China

Gagnepain in 1924 in the third volume of Lecomte, *Flore générale de l'Indo-Chine* treated 78 genera and 205 species of Compositae. Sixty-eight of these genera (87%) and 67 of these species (34%) are common to China and Indo-China (Table III). This large percentage of common genera and species indicates that there is a close floristic relationship between these two countries. A careful analysis of the data presented in Table III reveals that this statement is only partially true. First, many genera of Compositae important in the natural flora of China are absent from Indo-China. For example, 15 of the 38 large genera of Chinese Compositae, such as *Cacalia, Ligularia, Taraxacum, Ainsliaea* etc., do not occur in Indo-China. Secondly, the genera best developed in China, having hundreds of species there, such as *Leontopodium, Anaphalis, Chrysanthemum, Saussurea, Artemisia,* etc. are represented in Indo-China by only 1–4 species. In China they occur chiefly in Hainan, Taiwan, Kwangtung and some in Fukien and Yunnan. Thus we may conclude that there is a close affinity between the Composite flora of the warmer regions of China and Indo-China. There is no outstanding geographical barrier between these two countries and, as might be expected, they have many species in common.

The genera of Compositae of Indo-China are all small. Of the 69 occurring in both countries there are 1365 species in China and only 199 species in Indo-China. The species/genus ratio for these genera are 19.8 for China and 2.88 for Indo-China. If it were not for the two pantropical genera *Vernonia* and *Blumea,* this ratio would be even lower for Indo-China.

Indo-China is not suited to Compositae and its contribution to the Composite flora of China is almost nil. Gagnepain described several new genera for Indo-China. Two of these, *Blumeopsis* and *Camchaya,* have been recorded from Yunnan. As there is a great chance of mistaking a localized adventive for an indigenous genus, all of Gagnepain's Indo-Chinese genera of Compositae await verification through comparative study with material from other parts of the world.

3. China and India

Hooker, in 1881, in the third volume of the *Flora of British India* (including Pakistan, Bhutan, Nepal and Burma) covered 127 genera and 591 species of Compositae. Ninety-four of these genera (74%) are common to China and India (Table III).

The Composite flora of India is richer than that of Indo-China. There are more genera in that country and some genera have as many as 60 species. Nevertheless, when the Composite flora of India is compared with that of China, it reveals that India is better represented at the generic level and rather poor in species. This is shown by the species/genus ratios of Compositae in the two countries. In China there are 2029 species for its 167 genera of Compositae, with an average of 12 species to each genus. In India there are only 591 species for its 127 genera, with an average of less than 5 species to each genus. The high generic number and the low species/genus ratio may be taken as an indication that India is a good meeting ground for the genera of Compositae characteristic of many of its neighboring countries, and a poor place for the generation of new entities in the evolution of the family. In regard to the Composite flora of China, there are more genera that migrate from China to India than in the opposite direction.

The high species/genus ratio of the Chinese Compositae is due to the occurrence of the 38 "large" genera (i.e., with ten or more species) in that country. With the exception of *Pertya*, these genera also occur in India, but only in *Vernonia* and *Blumea* are there more species in India than in China. In the rest of the 35 genera, India has far fewer species. In the following genera, for example, the numbers of species in China and India are respectively: *Aster* 137:14, *Leontopodium* 57:1, *Gnaphalium* 20:7, *Artemisia* 156:27, *Cremanthodium* 47:7, *Senecio* (including *Cacalia*) 220:63, *Saussurea* 279:39, *Cirsium* 59:8, *Ainsliaea* 47:4, and the *Crepis* complex 96:14. Moreover, in India, the number of species belonging to these genera is largest for the northern provinces, especially the southern slopes of the Himalayas, and becomes gradually less toward the central and southern provinces. Obviously, in the distribution of these genera, India is on the periphery of their range. In these large genera, there are many species common to China and India, e.g., *Aster altaicus, A. tibeticus, Anaphalis cuneifolia, A. triplinervis, Artemisia glauca, A. desertorum* and *Saussurea deltoides*. *Saussurea* is one of India's largest genera of Compositae. Twenty-nine of its thirty-nine species (almost two-thirds) also occur in China. Many of them are recorded only from the Himalayan region of India, but are widespread in China.

There are 15 other genera of the 94 common to the two countries which have more species in India than in China. These are: (1) *Blumea*, (2) *Cotula*, (3) *Dichrocephala*, (4) *Emilia*, (5) *Laggera*, (6) *Pluchea*, (7) *Sphaeranthus*, (8) *Vernonia*, (9) *Allardia*, (10) *Carthamus*, (11) *Cousinia*, (12) *Launaea*, (13) *Pulicaria*, (14) *Cyathocline*, and (15) *Tricholepis*. Genera 1–8 are pantropical elements, occurring in Africa, Asia, America and Australia. In the course of their migration, they may have reached China by way of India or Burma, or they may have been introduced from other tropical regions to tropical China independently. Genera 9–13 are central Asiatic or Mediterranean entities. There are many possible routes for their migration to China. Again, India, because of her more numerous chances for communication with the Arabic world, may have supplied routes for the migration of these genera to China, especially through the Gangetic plains. Thus genera 1–13 cannot be considered as Indian influences on the flora of China. Genera 14 and 15 (*Cyathocline* and *Tricholepis*) are native of India and are Indian contributions to the Composite flora of China. The number of their species is small, and their effect on the flora of China is slight, however.

Twenty-eight genera of Indian Compositae are absent from China. Twelve of these are genera endemic to India, occurring chiefly in the western peninsula (7 genera, e.g. *Centratherum*) but also in central India (2 genera, e.g. *Lagascea*), the western Himalayan region (2 genera, e.g. *Catamixis*), and northern India (the genus *Caesulia*). The remaining 16 genera have a wider distribution. Some of them extend from India westward through Africa to the Canary Islands (*Ifloga*), or to the Mediterranean region or Europe, (*Volaturelia*), or to western or central Asia (*Epilasia*). Others are tropical genera occurring also in America, Australia and Africa (e.g., *Sclerocarpus* and *Chrysogonum*).

4. China, Central Asia and Siberia

Fedtschenko, in 1903 in his *Flore du Pamir*, covered 25 genera and 61 species of Compositae. All of them, except *Kentrophyllum* and *Pterotheca*, are genera common to China and Pamir (Table III). Tribes Vernonieae, Eupatorieae, Mutisieae and Heliantheae are absent from Pamir. Senecioneae and Inuleae are very poorly represented, the former tribe with 4 species (3 in *Senecio* and 1 in *Ligularia*) and the latter tribe with only two species (1 each in *Leontopodium* and *Inula*). Cichorieae and Astereae are weakly represented in Pamir. The best developed tribes in this region appear to be the Cynareae and Anthemideae. The largest genus is *Artemisia*, which has 20 species. *Cousinia* is the only genus that has more species in Pamir than in China. For the comparable genera, the species/genus ratios are 63.5 for China and 2.5 for Pamir. The overwhelmingly large number of Chinese species in most of the common genera of these two regions seems to indicate that Pamir has had very slight influence in the development of the Composite flora of China.

Krylov, in 1949 in his *Florae Sibiriae Occidentalis*, treated 68 genera and 399 species of Compositae. Fifty-two of these genera are common to China and Siberia (Table III). Tribes Vernonieae and Eupatorieae are absent from western Siberia. Mutisieae are represented by only one species. Heliantheae are represented by only two genera, these famous for their weedy species. In fact, three out of the five Siberian species of this tribe are widespread taxa in China.

Twenty-five of the large genera in China also occur in western Siberia. All of them except *Hieracium* have much smaller numbers of species. For the comparable genera there are 1729 species in China, with an average of 33 species to a genus, and only 397 species in western Siberia, with an average of 7 species to a genus.

The only genera that have approximately the same number of species in the two regions, or slightly more species in Siberia, are *Pyrethrum, Doronicum, Centaurea, Tragopogon, Achillea, Chondrilla* and *Hieracium.* It is very likely that in these genera the Chinese Composite flora expresses the influence of the Siberian elements.

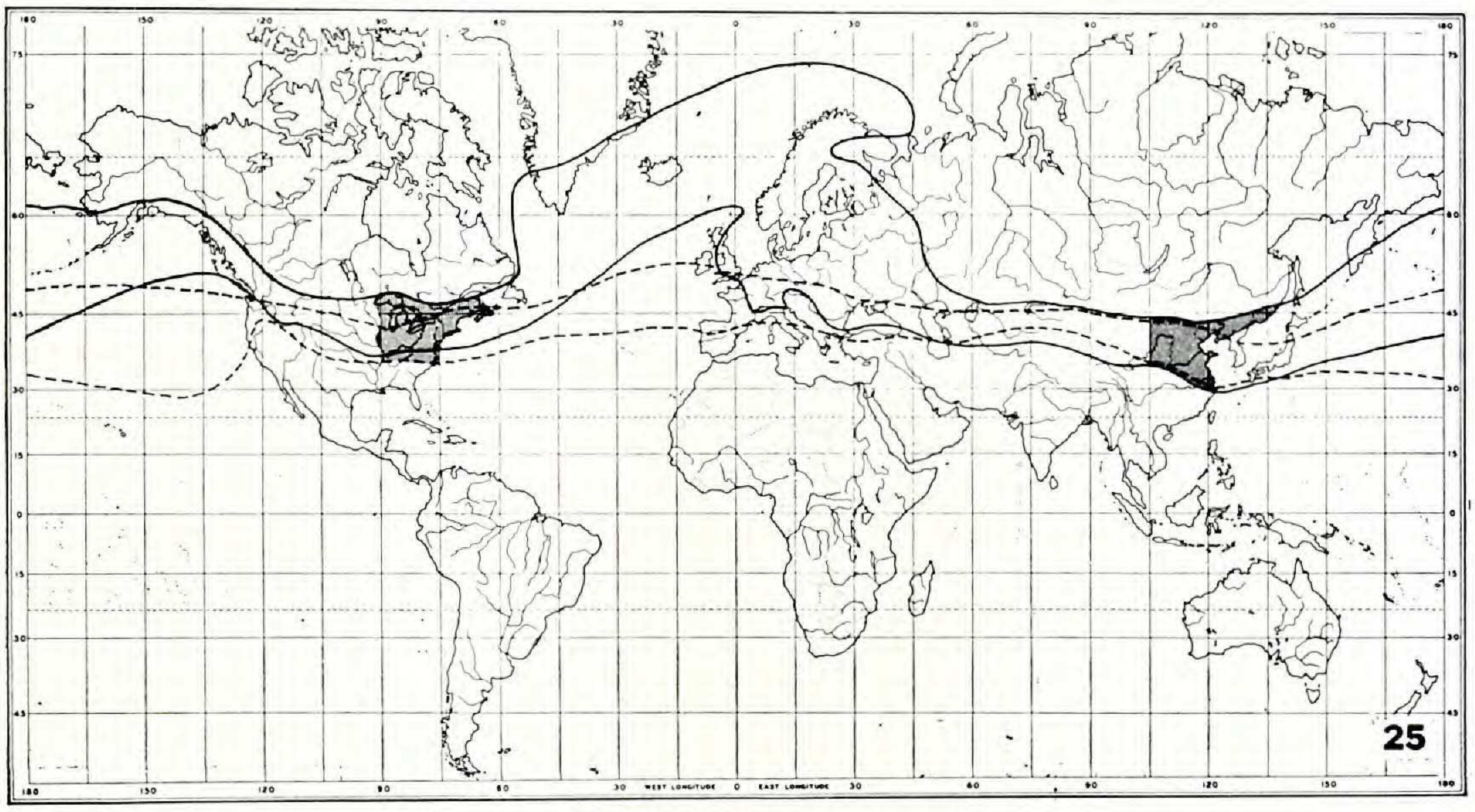
IV. A COMPARISON OF THE COMPOSITAE OF CHINA WITH THOSE OF NORTH AMERICA

The recognition of the identity or close similarity of angiospermous genera of eastern Asia and eastern North America is as old as the history of plant taxonomy. This relationship was known before the publication of Linnaeus' *Species Plantarum.* In a proposition prepared for the debate of a student, J. P. Halen, who was the respondent of the thesis entitled "*Plantae Camschatcenses Rariores,*" Linnaeus in 1750 pointed out this affinity by listing 11 species which were supposed to be common to North America and Siberia (Linn. Amoen. Acad. **2**: 336. 1752). About 1840 Asa Gray became keenly interested in the relationship of the flora of Japan to that of the temperate part of North America. In a book review on Siebold and Zuccarini, *Flora Japonica* (Am. Jour. Sci. Art. 39: 175–176. 1840), Gray selected 14 species of the ornamental or otherwise generally interesting plants of Japan and contrasted them with their closely related North American forms. His interest in discovering the relationship of the vegetation of the eastern sides of the two great continental masses in the northern hemisphere lasted for a long time. By 1856, in his *Statistics of the Flora of the Northern United States*, he concluded that there were more genera characteristic of eastern North America that it shared with an antipodal region, eastern temperate Asia, than with its neighboring district, western North America.

Among his examples of extra-European genera common to eastern North America and eastern Asia, Gray listed six genera of Compositae, namely, *Vernonia, Elephantopus, Diplopappus, Pluchea, Eclipta* and *Cacalia.* At that time the flora of China was practically unknown to the botanical world. Our knowledge of that rich flora did not commence to develop until some French missionaries, including David, Farges and Delavay, sent their collections from Szechuan and Yunnan to Paris. Our summary of the data scattered in publications on the Chinese flora yields 72 genera of Compositae which are common to China and North America. They belong to 10 tribes, namely Vernonieae, Eupatorieae, Astereae, Inuleae, Heliantheae, Helenieae, Anthemideae, Senecioneae, Cynareae, and Cichorieae.

An analysis of the numerous articles dealing with the floristic relationships of eastern Asia and eastern North America reveals that the authors have built up their evidence and accordingly drawn their conclusions from areas that are not comparable in size, climate, degree of rainfall or other factors which directly and indirectly affect the development and composition of vegetation. Actually, these authors were comparing a rather limited area of the eastern United States with the entire "China Proper," which includes all the regions commonly known as "North China," "South China," "East China," "Central China," "West China," "the Southwest" and "the Northwest." Some authors also included the Northeast, Korea and Japan. These names, to the people in China who use them daily, do not refer to regions with defined boundaries. Rather, they signify territories radiating from the better-known metropolises over a distance of one to three hundred miles. These centers are Peking and Tensin in the North, Nanking and Shanghai in the East, Canton and Foochow in the South, Wu-Han (Wuchang-Hanchow) in central China, Chengtu and Chungking in the West, Kunming in the Southwest, Sian and Lanchow in the Northwest, and Mukden and Harbin in the Northeast. Any general physical atlas (for example, Plate 3 of Bartholomew's *The Times Survey Atlas of the World*) would show that eastern Asia, as such, includes a much greater area, a more varied physiography, and more greatly diversified climate and related ecological conditions, than does eastern North America. For this reason, some of the conclusions drawn by eminent phytogeographers on the floristic interrelations of these regions are rather misleading. When the vegetation of comparable areas of eastern China and eastern United States is analyzed, and when the known cultigens and adventives are excluded, the corresponding area of eastern China does not have two or three times as many genera as that of eastern United States, as some authors have claimed. In the case of Compositae, for example, the contrary is true. There are far fewer genera and species in the corresponding part of China. Moreover, the same analysis of the genera and species of Compositae gives no evidence to confirm Gray's well-known conclusion that eastern North America shares more genera with its antipodal region in eastern Asia than with its neighboring district of western North America.

In outlining comparable areas of eastern China and eastern North America the extreme low temperature and the amount of annual rainfall are considered as the determining factors. For obvious reasons the area covered by Fernald's eighth edition of Gray's Manual is chosen as the basis for a comparison. MAP 25 shows that the January temperature of this area varies from 10°F. in the north to 40°F. in the south, and the annual mean temperature is approximately 60°F. The corresponding area in China has a more southerly limit in the coastal area which reaches the 30th parallel. Fernald's area on the North American mainland extends approximately over Long. 65°–96°W. and Lat. 26°–50°N. (shaded area of map). The area in China with the same annual isotherms and approximately the same length of growing season falls on Long. 104°–135°E. and Lat. 30°–47°N. (shaded). In China this area covers parts of Kirin and Heilungkiang, Liaoning, Jehol, Chahar, Suiyuan, Shensi, Shansi, Shantung, Hopei, Honan, Kansu, northern Chekiang, Anhwei, Hupei and eastern Szechuan. The physical features of the land-mass are of very ancient formation. The eastern portion of this area constitutes the alluvial plains of the Lower Yangtze River, the Yellow River, the Liao-ho and the Sungari River. The western portion of the area is an old plateau. The area includes many famous ranges where classical botanical collections were made in the last hundred years. Tsingling (including Tai-po Shan, 2000–4000 m.), Alashan (2000 m.), Lu-pan Shan, Taihang Shan, Ta-ching Shan, Wu-tai Shan (3040 m.), Chang-po Shan, Tai Shan and Tien-mu Shan are the well-known explored mountains. In rainfall and general climate this area is comparable with Fernald's area. Both of them have warm or hot summers and cold winters, and both have a mean annual rainfall of 20–40 inches.



MAP 25. World map showing comparable areas of eastern China and eastern North America (shaded). Solid lines mark the area with temperatures varying from 10° F. in the north to 40° F. in the south during January. The broken lines mark the area with an annual mean temperature of 60° F.

Regarding the Compositae, Fernald treated 115 genera, 82 of which are native and 33 introduced. In the comparable area of China there are 94 genera of Compositae, 27 of which are known to have been introduced as cultigens or weeds. A comparison of Fernald's 115 genera with the Compositae of China indicates that 47 of them occur in China at large, and only 37 of them occur in the corresponding area. Evidently of the genera of Compositae common to the two countries, only about four-fifths are shared by the corresponding area in China. A detailed comparison of these common genera is presented in TABLE IV. The total number of species for China at large and that for the northwestern United States, as included in Hitchcock's *Vascular Plants of the Pacific Northwest*, are also given for reference. The abbreviations in the column for Fernald's area are: E = naturalized from Europe, T Am = adventives of tropical America, A = naturalized from Asia. For the corresponding area in China, such an accurate record is lacking. The relatively short botanical history and the prolonged period of human activities in the area make it forever impossible to ascertain the origin of certain of its extra-Chinese elements of Compositae. These genera, the center of species concentration of which are known to be in the Americas, the Mediterranean region, or western or central Asia, are marked with (?).

TABLE IV. **A Comparison of Genera of Compositae Common to Limited Areas of China and North America**

GENUS	NO. OF SPP. IN CHINA AT LARGE	NO. OF SPP. IN COMPARABLE AREAS OF CHINA	NO. OF SPP. IN FERNALD'S RANGE	NO. OF SPP. IN HITCHCOCK'S AREA
Vernonia	34	4(?)	7	0
Elephantopus	2	0	3	0
Eupatorium	17	9	26	2
Mikania	3	0	1	0
Solidago	5	4(?)	75	10
Aster	137	43	68	34
Erigeron	25	7	17	62
Anaphalis	51	7	1(E)	1
Antennaria	2	0	32	25
Gnaphalium	20	7	10	8
Pulicaria	4	1	1(E)	0
Adenocaulon	2	2	1	1
Xanthium	2	1(?)	15	2
Acanthospermum	1	0	1(T Am)	0
Parthenium	1	0	3(T Am)	0
Eclipta	1	1(?)	1	0
Rudbeckia	1	0	19	3
Spilanthes	2	0	1	0
Bidens	6	6(?)	19	6
Galinsoga	1	0	4(T Am)	1
Achillea	10	5	5(E, A)	1
Chrysanthemum	37	33	4(E)	3
Cotula	2	0	1(A)	1
Matricaria	4	4(?)	3(E)	2
Artemisia	158	81	17	24
Tussilago	1	1	1(E)	1
Petasites	9	2	4(E)	2
Erechtites	2	0	2	3
Cacalia	60	23	4	0
Senecio	160	27	22(E, A)	33
Echinops	11	4	1(E)	1
Arctium	2	2(?)	4(E)	2
Carduus	11	5	3(E)	3
Cirsium	59	16	17(E)	16
Silybium	1	1(?)	1	1
Centaurea	7	6	12(11 E)	10
Hypochoeris	3	2(?)	1(E)	0
Cichorium	2	2(?)	2	1
Lapsana	3	3(?)	1	0

TABLE IV. (*Continued*)

Tragopogon	10	3	3(E)	5
Picris	8	2	2(E)	0
Taraxacum	57	22	11(some E)	5
Sonchus	10	4	4(E)	4
Lactuca	57	23	16	6
Prenanthes	19	5	10	2
Crepis	31	2	5(some E, A)	11
Hieracium	14	4	19	8

Several noteworthy points on the floristic relationship as expressed by the Compositae of the two areas can be drawn from the above data. First, in regard to the number of native genera, Fernald's area has 82, while the corresponding area in China has 67, which is one-fifth less than in Fernald's area.

Secondly, regarding the genera common to the two areas, in Fernald's area 22 out of the 47 genera which also occur in China are naturalized or adventive. The adventives of tropical American origin, such as *Parthenium*, *Galinsoga*, *Acanthospermum*, etc., occur in the warmer regions of China, but they are absent from the corresponding area under discussion. This phenomenon may indicate one of the two or both measures: that northeastern North America supports more elements of the warmer regions than the corresponding area in Asia, and that due to the longer distance and the shorter period of communications between this part of Asia and tropical America these elements have not yet been introduced or established.

Thirdly, among the common genera native to both areas there are nine genera which have far more species in Fernald's area (*Eupatorium*, *Solidago*, *Aster*, *Erigeron*, *Gnaphalium*, *Xanthium*, *Bidens*, *Prenanthes* and *Hieracium*), while there are only three which have more species in the corresponding area in China (*Artemisia*, *Lactuca* and *Taraxacum*).

Lastly, among the native genera, only *Cacalia* is common to the northeastern North America and the corresponding area of China while absent from the Pacific Northwest. Meanwhile, there are three genera, *Antennaria*, *Rudbeckia* and *Erechitites*, which are common to the areas of Fernald and of Hitchcock and are absent from the corresponding area of China. In the Composite flora, there is no evidence that the northeastern North America shares a larger number of genera with a comparable area of eastern Asia than with her neighboring area in western North America.

V. THE REFLECTION OF COMPOSITAE ON THE VEGETATION OF CHINA

In the foregoing analyses I have presented the general features of the Chinese Compositae. Special emphasis was given to the constituent genera of the family and their distribution. What light can the knowledge of this overall picture of the largest family of flowering plants of China cast on the understanding of the vegetation of that country? The following discussion will be centered around this subject.

The Compositae reflect the very uneven floristic composition of the vegetation of China. If the distributional maps of the Compositae (MAPS 1–24) were superimposed on a single map, the resulting picture would have various shades of darkness, with the darkest area, representing the region richest in Compositae, falling over Yunnan, Szechuan and parts of their neighboring provinces, and the lightest area, representing the poorest region, falling over Honan, Kiangsu, Shantung and parts of their neighboring provinces. What is true of Compositae is also true of the general vegetation. The region with the largest number of genera and species of Compositae is also the richest floristic region in China, and the region poorly represented with Compositae is also poor in natural vegetational coverage.

1. THE AREA RICHEST IN COMPOSITAE SUPPORTS THE RICHEST VEGETATION

The area of greatest floristic richness is very limited, being formed by the Meridional Ranges which extend from western Yunnan northward to eastern Sikang, western Szechuan and the adjacent territory in Kansu and Shensi. Here, in order to present the vertical distribution of the predominant genera of the Compositae in these mountains, a brief account of the complex physiography, which results in sharp changes of elevation and climatic differentiation, is also given. The consequent diversified types of vegetation are then described more fully.

This region consists of very ancient formations characterized by high mountains and deep gorges. The mountains are formed mainly from mud-shales and granitic rocks. Occasionally limestones have been forced up through the older rocks to form bold peaks and stupendous precipices. At the bottom of the deep gorges flow torrential tributaries of seven large rivers which are, from west to east, the Chiukiang, Salween, Mekong, Chinshakiang, Yalungkiang, Tatuho and Min Rivers. Most of the tributaries drain from mountains capped with perpetual snow. The principal courses of the seven rivers all run from north to south, parallel to the meridian and hence the mountains are known collectively as the Meridional Ranges.

At lower altitudes, the valleys of the large rivers are bordered by deeply eroded treeless mountains. The climate here is hotter and drier than the altitude warrants and barren areas and desert-like vegetation are common, with *Artemisia* and *Inula* predominant among the Compositae. As one ascends the mountains along the tributaries of the rivers, the change in topography and vegetation is sudden. Gentle slopes are inhabited by various tribes, such as the Lolo, Miao, Chiarung, Ch'iang, etc., and up to about 7500 ft. all the arable land is cultivated, the natural vegetation being greatly disturbed. The slopes which are too steep to reach, and the areas which are too far from human dwellings are covered with mesophytic forest. Trees, shrubs and herbaceous undergrowth flourish. The muchtravelled and experienced collector, E. H. Wilson, considered this zone to have one of the world's richest vegetations. Along the roads skirting the banks of the streams, on the edges of the forests, or on drier grassy slopes are many species of *Artemisia*, *Crepis*, *Aster*, *Eupatorium*, *Gnaphalium*, *Arctium*, *Carpesium*, *Erigeron* and *Tussilago*. The slopes from 7500–9000 ft. are covered by mixed forests of many species of deciduous trees and conifers. On the southern flanks of the mountains bamboo forests, mixed with some deciduous or evergreen trees are common. In the forests or on the flood plains species of *Senecio*, *Anaphalis*, *Cirsium*, *Ainsliaea* and *Gerbera* are common. From 9000 ft. to timber line the slopes are covered with virgin coniferous forests. The Composite family is rather poorly represented in this zone. Above timber line, in the alpine meadows, with the extraordinarily rich assemblage of herbaceous types, the family has its best development. Many species of *Artemisia*, *Saussurea*, *Dubyaea*, *Soroseris*, *Cremanthodium*, *Ligularia*, *Aster* and *Jurinea* form pure colonies. Many others growing mixed with grasses, sedges, *Aconitum*, *Saxifraga*, *Delphinium*, etc. are found. It is not an exaggeration to call the alpine meadows of the Meridional Ranges the Land of Compositae. On the razor-like ridges species of *Leontopodium* and *Anaphalis* form colonies. In fact, species of Compositae can be found in all kinds of habitats in the alpine region of the Meridional Ranges. In places where no other flowering plant thrives, species of Compositae grow. Thus, immediately below the perpetual snow line, in the rock cracks where there is a thin veneer of wind-blown soil, one may find different species of *Saussurea* and *Soroseris*.

In considering the floristic richness of this area it must be remembered that the seven rivers have hundreds of tributaries. Thus, in a very limited region, the complicated habitats and the diversified vegetation are repeated several hundred times. The proximity of subtropical swamps, semi-desert scrubs, mesophytic forests, grassy slopes, bamboo woods, coniferous forests, alpine meadows and high-altitude tundra provide unusual opportunities for the close contact of many species. This brings about unique chances for the hybridization of related forms. In many places these diversified habitats can be found within five miles of one another. The heterogeneity of external conditions induces mutation and accelerates speciation. Frequent landslides after the annual monsoon storms, or occasional earthquakes, provide new habitats for the colonization of new forms. All these conditions are contributing factors to the rich Composite populations of the Meridional Ranges.

As stated before, the region that is richest in Compositae is also the land with the richest vegetation in China. It is rich in gymnosperms and there is no comparable region in the world that has so many species of *Taxus*, *Cephalotaxus*, *Larix*, *Abies*, *Picea*, *Tsuga* and *Juniperus* as the Meridional Ranges in China. It is rich in broad-leaved trees and shrubs. In fact, this region is the homeland of many garden specialties, especially those in the genera *Acer*, *Akebia*, *Berberis*, *Camellia*, *Clematis*, *Cotoneaster*, *Deutzia*, *Euonymus*, *Hydrangea*, *Ilex*, *Jasminum*, *Kerria*, *Lonicera*, *Nandina*, *Paeonia*, *Rhododendron*, *Rosa*, *Syringa*, *Viburnum*, etc. It is particularly rich in herbaceous types. Species of *Aconitum*, *Allium*, *Anemone*, *Corydalis*, *Cypripedium*, *Delphinium*, *Dianthus*, *Fritillaria*, *Lilium*, *Polygonum*, *Potentilla*, *Rheum*, *Ranunculus*, *Saxifraga*, *Sedum*, *Thalictrum*, etc. are very numerous. There is no place in the world that can surpass this region in the number of species of *Primula*, *Gentiana*, *Meconopsis* and *Pedicularis*. It is also rich in monotypic or oligotypic families and genera. *Aucuba*, *Alangium*, *Coriaria*, *Delavayia*, *Dipteronia*, *Eucommia*, *Euptelea*, *Euscaphis*, *Helwingia*, *Stachyurus* and *Tetracentron* are only a few examples. They are important constituents of the mesophytic forests of the region. As the mountains of this region generally reach 12,000–16,000 ft., alpine vegetation reaches the peak of its development. Grasses and sedges are numerous both in kind and in individuals. The southern portion of the region reaches the subtropics. The north-south direction of the valleys of the main rivers favors the movement of tropical monsoon rainfall farther north than the latitudes warrant. Species characteristic of the warmer regions are well developed in the lower elevations. *Cycas*, *Podocarpus*, palms, bamboos, lauraceous trees and shrubs, and large woody leguminous vines characteristic of the tropical rain forests are abundant in the jungles at low elevations. The experienced explorer F. K. Ward, after visiting the southwestern corner of this region, called it the "Plant Hunter's Paradise." E. H. Wilson, after going through the northern portion of the region, commented upon it as being the richest area in vegetation on earth. The entire area is highly significant in the vegetation of China.

2. The Area Poorest in Compositae has the Poorest Vegetation

This area is called the Central Plain (Chung-yuan) in ancient Chinese literature. It is the plain on which the ancient history of China was built. Even in modern times it is still the focal point in the struggle for power among the war lords, for whatever party gets this area gets control of the national government. In modern geography and in current news this area is called the North China Plain. In size it is approximately equal to the region which has the richest vegetation, but in its physiography it is very different.

Geographically this plain is the alluvial fan formed by the Yellow River. It covers central and eastern Honan, southeastern Hopei, western Shantung, northern Kiangsu and northern Anhwei. Throughout the territory no elevation exceeds 200 ft. above sea level, excepting in northern Kiangsu, where there are a few low, barren hills up to 600 ft. high. On the Kiangsu-Anhwei border in the south there is a swampy lake, Hung-tse-hu, and on the Kiangsu-Shantung border there is a similar lake, the Wei-shan-hu. The changeable courses of the lower Yellow River radiate like the ribs of a fan with Loh-yuan at the pivot, Tiensin on a rib to the north, and Suchow on another rib to the south.

Geologically this area is a new land. It is so new that the configuration of the surface has undergone noticeable changes in the last fifty years. Around my home village (Kiangsu Province), the heavy deposits of the frequent floods, so frequent that thirteen floods occurred in the summer of 1924, have elevated the land up 3 ft., and the repeated erosions have converted a former road into a river.

Historically this area is one of the earliest inhabited spots of the world. The discovery of the Peking man, *Sinanthropus pekinensis*, in 1928, materially proves this proposition. The rich alluvial land, the temperate climate of this latitude and the timely rainfall, the maximum of which occurs in July, all favor the development of agriculture. For four thousand or even more years, the people in this area have been farmers. It is estimated that at present every square mile of the cultivated land in this region supports 1479 people. Ninety per cent of them are farmers, who obtain their entire livelihood from the products of the soil. For at least four thousand years men have reshaped every inch of the land in this area, and there is no spot with natural vegetation. All land surfaces that can possibly be cultivated are utilized. The small lots of farm land are carefully tilled. There are no farms in the world that have so few weeds as the farms in this area. Natural resources are utilized to the limit. After the planting of winter wheat, and the harvesting of sweet potatoes and carrots, for hundreds of miles at a stretch the land is of one brown color. The fields are turned over. The fallen leaves are collected for fuel. The herbs on the roadsides, or along the banks of canals are carefully scraped off with a thin veneer of the top soil. When dry, the mixture of plants and earth is collected and used for spreading over the floor of the animal house in winter. Eventually this becomes the fertilizer for the fields the next spring.

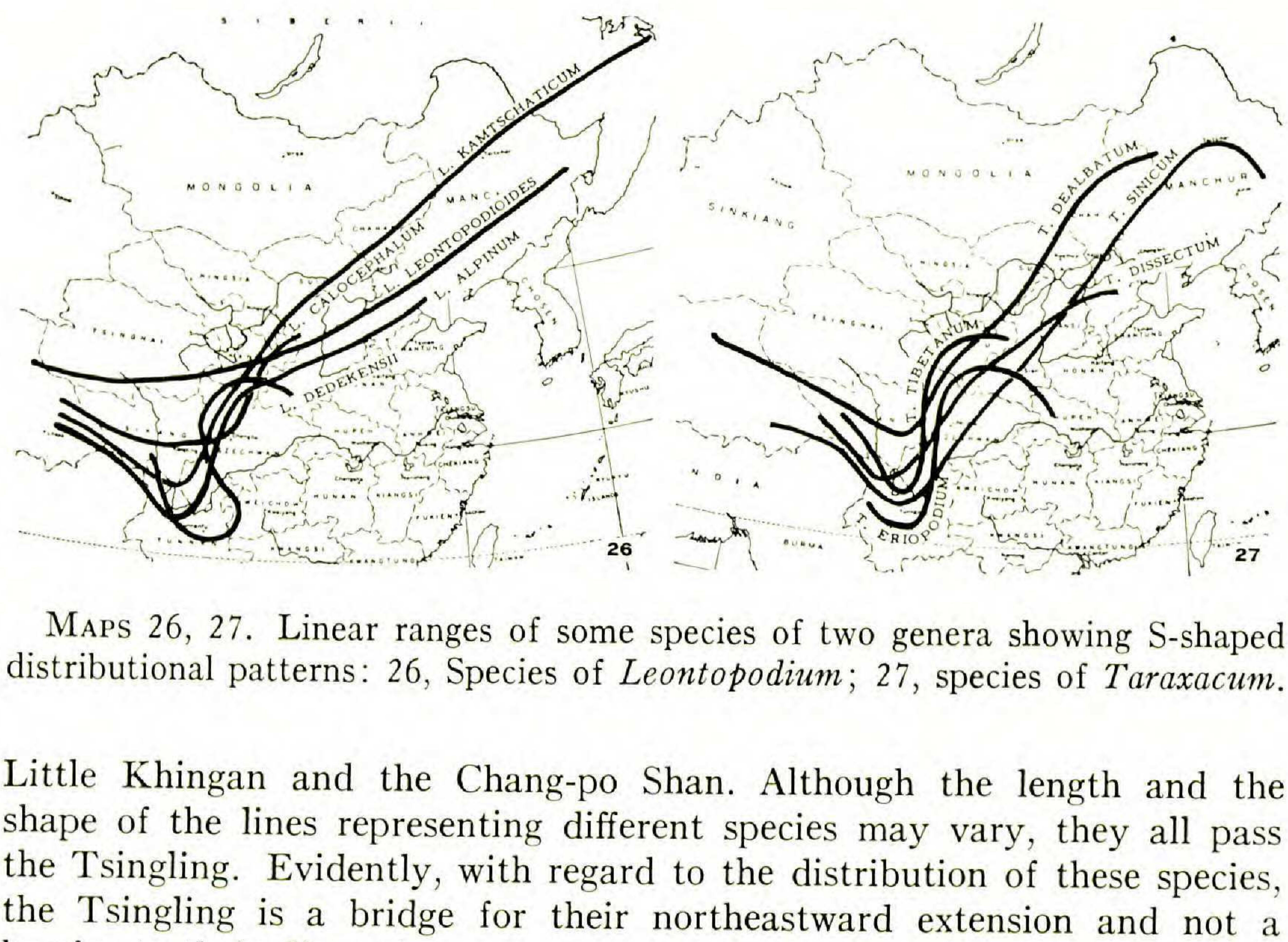
Under such intense utilization of land, the species of Compositae occurring in the area, with the exception of the cultivated forms, are no more than can be counted on the fingers of two hands. These are all widespread weeds. *Eclipta alba* is common in gardens and cotton or soybean fields. *Cirsium lineare* is common in kao-liang (*Sorghum*) fields. *Lactuca tartarica* and *Artemisia campestris* occur in alkaline soil. *Saussurea affinis* and *Ixeris chinensis* occur in gardens and graveyards. *Artemisia annua* and *Xanthium strumarium* occur on village commons. *Inula britannica* occurs in protected woods on the outskirts of villages. *Bidens chinensis* and *Taraxacum officinale* occur in graveyards. *Scorzonera albicaulis* is limited to the arid region of the barren hills. With the exception of *Eclipta* and *Cirsium*, the occurrence of all the above-mentioned species is occasional. Thus the Composite flora of this area is poor in the number of individuals as well as poor in kinds.

The region poor in Compositae is also poor in other vegetation in China. Forests are unknown to this area. Woods protected by temples or well-to-do families are rather rare. The component species are few. *Thuja orientalis, Salix babylonica, Populus alba, Juglans regia, Castanea mollissima, Ulmus pumila, Ulmus parvifolia, Morus alba, Sophora japonica, Ailanthus altissima, Melia azedarach* and *Euonymus bungeanus* are the common species. *Lycium chinensis* and *Tamarix chinensis* are often found in long stretches of sand which may mark the course of a former river. Herbaceous species are also few. *Cynodon dactylon, Eleusine indica, Im-*

perata cylindrica, *Miscanthus sacchariflorus*, *Eremochloa colonum*, *Digitaria sanguinalis*, *Chenopodium album*, *Amaranthus viridis*, *Celosia argentea*, *Acalypha australis*, *Apocynum sibiricum*, *Galium aparine* and *Mazus rugosus* are the common species.

3. The Characteristic Ranges of some Subgeneric Taxa in China

Maps 26 and 27 represent the linear distribution of several species of *Leontopodium* and *Taraxacum*. This is done by drawing a line through the provinces where the species under discussion has been recorded. It is interesting to note that the lines representing the distribution of each species form a more or less modified S-shape. Looking at these distributional lines by provinces they connect Tibet, Sikang, Yunnan, sometimes Kweichow, Szechuan, Kansu, Shansi, Shensi, Hopei or Suiyuan and Mongolia or Chahar, Heilungkiang, Kirin and Liaoning. Looking at them by topography, they link up the Tibetan Plateau, the Meridional Ranges, the Tsingling, the Taihang Shan or the Yin Shan, the Great Khingan, the



Maps 26, 27. Linear ranges of some species of two genera showing S-shaped distributional patterns: 26, Species of *Leontopodium*; 27, species of *Taraxacum*.

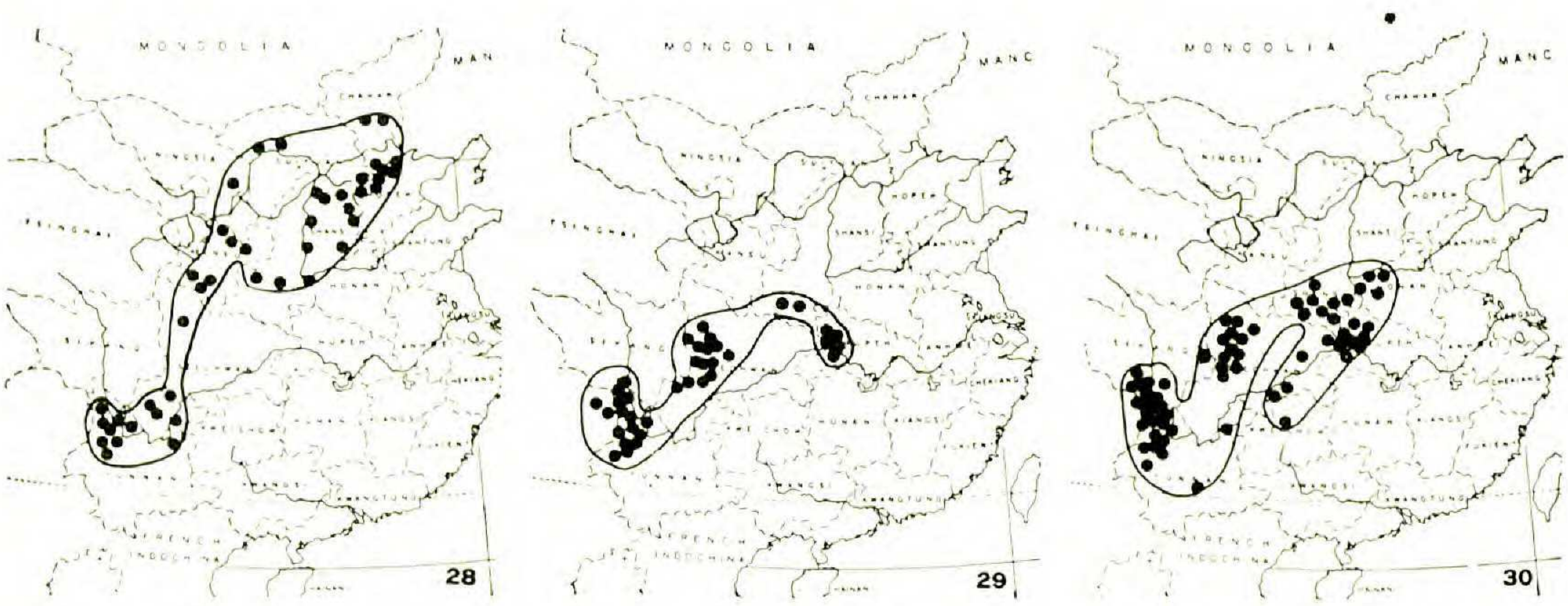
Little Khingan and the Chang-po Shan. Although the length and the shape of the lines representing different species may vary, they all pass the Tsingling. Evidently, with regard to the distribution of these species, the Tsingling is a bridge for their northeastward extension and not a barrier to their dispersion.

Geographers in describing the physiognomy of China have emphasized the ill effect of the Tsingling on the unity of the country. They have also created a misleading impression that the Tsingling Range has been a barrier to the distribution of animals and plants. For example, one author (Cressey, 1934. p. 14–15) wrote, "Greatest of all the mountains of China is the eastward extension of the Kuen Lun, known in China collectively as the Tsingling Shan. . . . The mountains divide China into two major geographical regions, characterized by striking contrasts in climate, agriculture and human activities. . . . There are two Chinas, each with distinct characteristics in sharp contrast to those of the others. . . . One China is in the South, a land of abundant rainfall. . . . This is the land of . . . rice and bamboo . . . the people are shorter in stature. . . . The other China is in the North, a land of limited and uncertain rainfall. . . . The standard crops are millet and Kaoliang and beans. . . . The people are taller. . . . The South tends to be radical and revolutionary, while the north is stolid and conservative. . . . The boundary between the North and the South is transitional . . . it coincides with the crest of the Tsingling Shan." Another author (Lee, 1939, p. 2) in a more concise manner maintained, "The Tsingling Range forms the natural divide between northern China and the Yangtze Valley . . . these ranges that have naturally sharpened the climatic contrasts and regional differences in other geographical conditions, against which the Chinese have struggled for their unity during historical time."

Actually whether Tsingling does have such far-reaching influence on the physical conditions of the land, on the distribution of plants and animals, and on the life of the people is questionable. First, the mountains constituting the Tsingling Range are of unequal heights. As the range extends from the border of Kansu-Szechuan-Shensi eastward to Hupei, Honan and Anhwei, the elevation is gradually reduced. In the west the mountains are continuous and often snow-capped, but to the east they seldom reach 600–1200 ft. in altitude. Moreover, there are many broad gaps from Hupei eastward, and in Kiangsu Province there are only plains and hills. The differences in climatic conditions and human activities described in the foregoing quotations are found in the low land where the tail-end of Tsingling is not high enough to be a climatic barrier. Actually the people living to north and south in the mountains of the western end of Tsingling have much more in common than those living in the plains in the east where there are no mountain barriers. For example, the people in the mountains of Szechuan, south of Tsingling, and those of Labrang in southwestern Kansu, north of the Tsingling, have more in common than the people of Suchow and Shanghai, both in Kiangsu Province. Likewise in plant distribution the high mountains constituting the western portion of Tsingling are bridges over which the montane and alpine elements of the south extend to the higher latitudes of the north and the boreal elements migrate to the high altitudes of the south. To regard Tsingling as a bridge and not a barrier in the distribution of plants of the subgeneric level is essential in the understanding of the vegetation of China.

In the Compositae many species in the genera *Aster*, *Chrysanthemum*, *Artemisia*, *Senecio*, *Cacalia*, *Leontopodium*, *Taraxacum*, *Ligularia*, *Saussurea* and *Lactuca* extend from Tibet, Yunnan, Szechuan or Sikang in the south, over the Tsingling Range to Shensi, Shansi, Kansu and even Hopei, Manchuria and Korea in the north. Linear connections of these distributions reveal an S-shaped pattern with Tsingling falling at the northern half beyond the middle. MAPS 26 and 27 illustrate the S-shaped distribution of the species of *Leontopodium* and *Taraxacum* which may be taken as examples of this type of distribution.

This is a pattern of distribution not limited to the Compositae alone, but a general pattern of distribution of many taxa at the subgeneric level. There are numerous examples in the Coniferae. Ostenfeld and Syrach-Larsen in *The Species of the Genus Larix* (p. 18) give a perfect S-shaped distribution of *L. potaninii*. In fact this species is closely related to *L. griffithiana* and *L. mastersiana*. Morphologically there is no clear-cut division between them. Their status as species depends largely on the temperament of the taxonomist. They can certainly be regarded as geographical variants. *Larix griffithiana* occurs also in Yunnan. Looking at the distribution of the group as a whole, the S-shaped range can be extended to the southern Himalayas. *Abies delavayi*, *A. georgei*, *A. forrestii*, *A. faberi*, *A. faxoniana* and *A. chensiensis* (French spelling for Shensi) present the same taxonomic problem, and form the same S-shaped range. These species are fairly distinct, but there are some intermediate collections.



MAPS 28–30. Distribution of three monotypic genera showing S-shaped ranges: 28, *Ostryopsis davidiana*; 29, *Tetracentron sinense*; 30, *Euptelea pleiosperma*. Each dot represents a collection in the herbarium of the Arnold Arboretum.

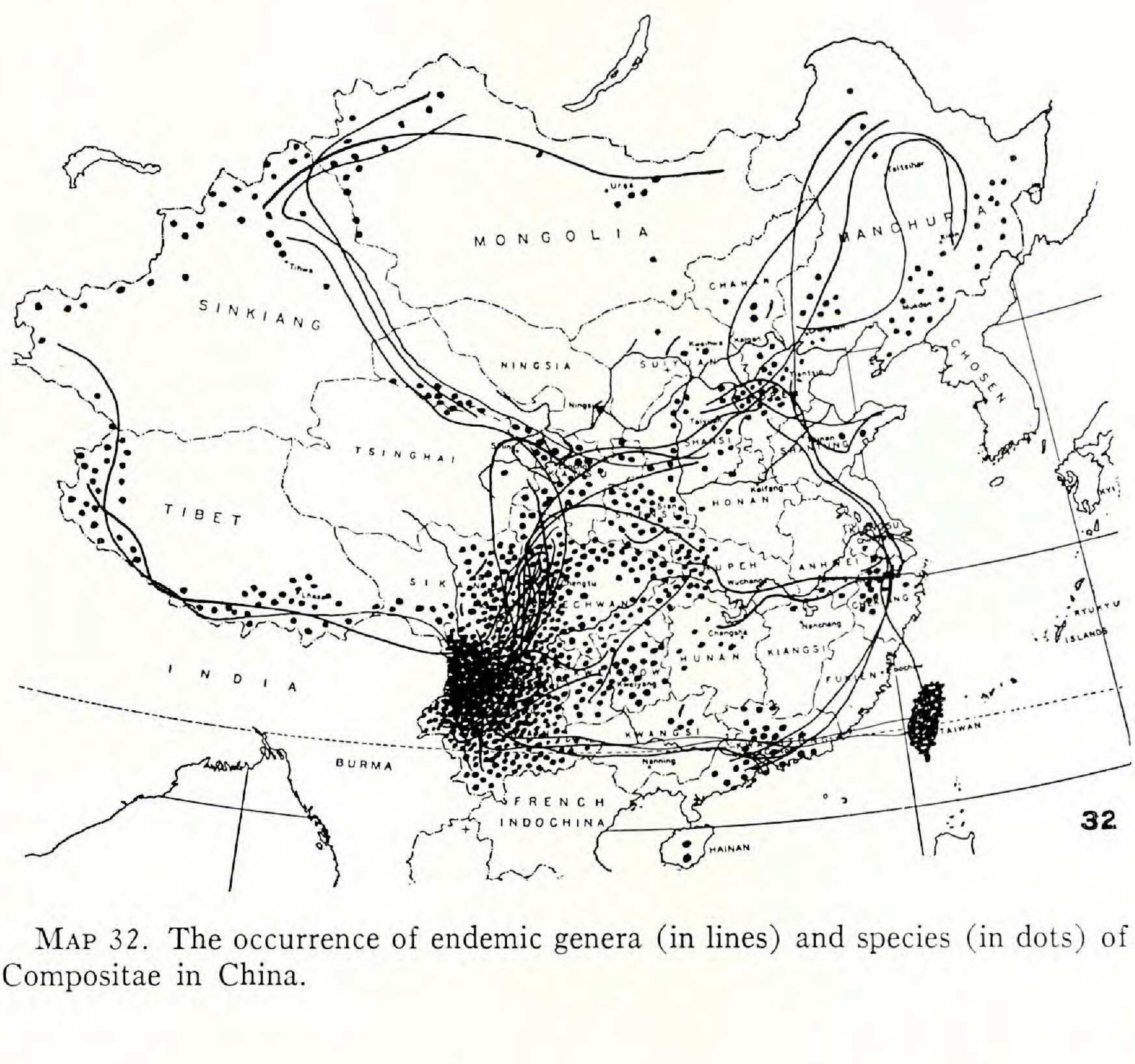
Another example of the S-shaped range is found in *Betula platyphylla*. This species is known to some botanists as *B. japonica* and to others as *B. mandshurica*. In this case the taxonomists are more conservative and the geographical variants are regarded as varieties. The five varieties of this species, *Betula platyphylla* vars. *rockii* (from Yunnan), *szechuanica* (Szechuan-Kansu-Shansi), *mandshurica*, *kamtschatica* and *japonica* form an elongated S-shaped range extending from Yunnan through the Meridional Ranges, the Tsingling, the Taihung Shan, the Yin Shan, the Khingan, the Changpo Shan to Kamchatka and Japan.

Many monotypic genera also have similar patterns of distribution. To cite a few examples, the two varieties of *Ostryopsis davidiana* (var. *cinerascens* and var. *nobilis* [Betulaceae]) form an S-shaped distributional pattern over northwestern Yunnan, western Szechuan, Kansu, Shensi, Shansi, Hopei and Chahar (MAP 28). *Tetracentron sinense* (Tetracentraceae) forms a shorter curve but with the same pattern over Yunnan, Szechuan, Shensi and Hupei (MAP 29). *Euptelea pleiosperma* (Eupteleaceae) forms an even more symmetrical S-shaped distributional pattern covering Sikang, Yunnan, Szechuan, Shensi, Honan, Hupei and Kweichow (MAP 30).

Many more cases can be cited from *Gentiana, Potentilla* and *Saxifraga* to illustrate the S-shaped distribution of subgeneric entities. In short it is conclusive that the mountain ranges including the Tsingling are bridges for the distribution of plants. It should also be noted that all the examples cited have small seeds which can be dispersed through adhesion to animals and man as well as by wind. In many cases closely related forms also occur in the northern Rockies. For example, *Larix occidentalis* and *L. potaninii, Philadelphus lewisii* and *P. tenuifolia* are morphologically twin species of the two continents.

4. ENDEMIC ELEMENTS

About one-third of the 167 recognized genera of Compositae in China are endemic to that country. Most of them are monotypic or oligotypic genera but several of them, such as *Cremanthodium* and *Youngia*, have from 30 to 60 species. The occurrence of the endemic genera and species of Compositae is illustrated in MAP 32. In this map the lines represent



MAP 32. The occurrence of endemic genera (in lines) and species (in dots) of Compositae in China.

monotypic or oligotypic genera and the dots represent species known only from the type localities. Evidently the occurrence of the endemic genera and species of Compositae is a widespread phenomenon in the country. There seems to be no restriction on where endemism may occur, but it appears clear that there are definite areas of concentration of the endemics. The Compositae of various regions of the country have been studied by botanists of different nationalities. The Japanese botanists have published very liberally on the flora of Taiwan and on that of northern or northeastern China. The Russian botanists have described many new genera and species from Mongolia and Sinkiang. British botanists have published new taxa from Tibet and Yunnan. French, Austrian, Italian and German botanists have published voluminously on the material collected from central China. Individual differences in background, technique and temperament on the part of these botanists naturally affect the quality of the new genera or species they described. Some of them "split" more than the others. Consequently the areas they work on appear to support more endemics. In addition to these inevitable human defects, there is still another difficulty which affects the value of the map showing endemism of Compositae in China. This difficulty is that some areas are better explored and more endemic elements have become known than in other areas. For these reasons questions may be posed as to the validity of specific cases on the occurrences of narrow endemics. Nevertheless, for the general trend of endemism in the flora of China, the endemic genera and species of Compositae present remarkable examples.

The Meridional Ranges, especially in northwestern Yunnan, have the highest degree of endemism in the Compositae, both on the generic and on the specific level. Many monotypic genera like *Vierrhapperia*, *Formania*, *Vladimiria* and *Leucomeris* occur only in Yunnan and others like *Wardaster* and *Bolocephalus* occur only in Sikang. Many oligotypic genera occur throughout the region forming S-patterns in Yunnan, Sikang, Szechuan and Kansu or Shensi. *Myriactis*, *Stereosanthus*, *Nouellia* and *Dubyaea* are a few examples. Some of them such as *Faberia* extend the range to Kweichow while others such as *Soroseris*, *Tricholepis* and *Myriactis* extend the range to Chinghai and Sinkiang or Tibet and North India. The high degree of endemism in the Meridional Ranges and the extension of some genera to the Himalayas, to Tibet or to Kweichow represent common patterns of the occurrence of monotypic or oligotypic endemic genera in the flora of China. For example, *Docynia delavayi* (Rosaceae), occurs only in Yunnan, while *Tetracentron sinense* (Tetracentraceae) is very numerous at mid-high altitudes both in Yunnan and Szechuan. *Euptelea pleiosperma* (Eupteleaceae), *Decaisnea fargesii* (Lardizabalaceae), and *Sibiraea laevigata* var. *angustifolia* (Rosaceae) are abundant in this region but with their ranges extended to India, Shensi, Hupei, or to Kansu and Sinkiang.

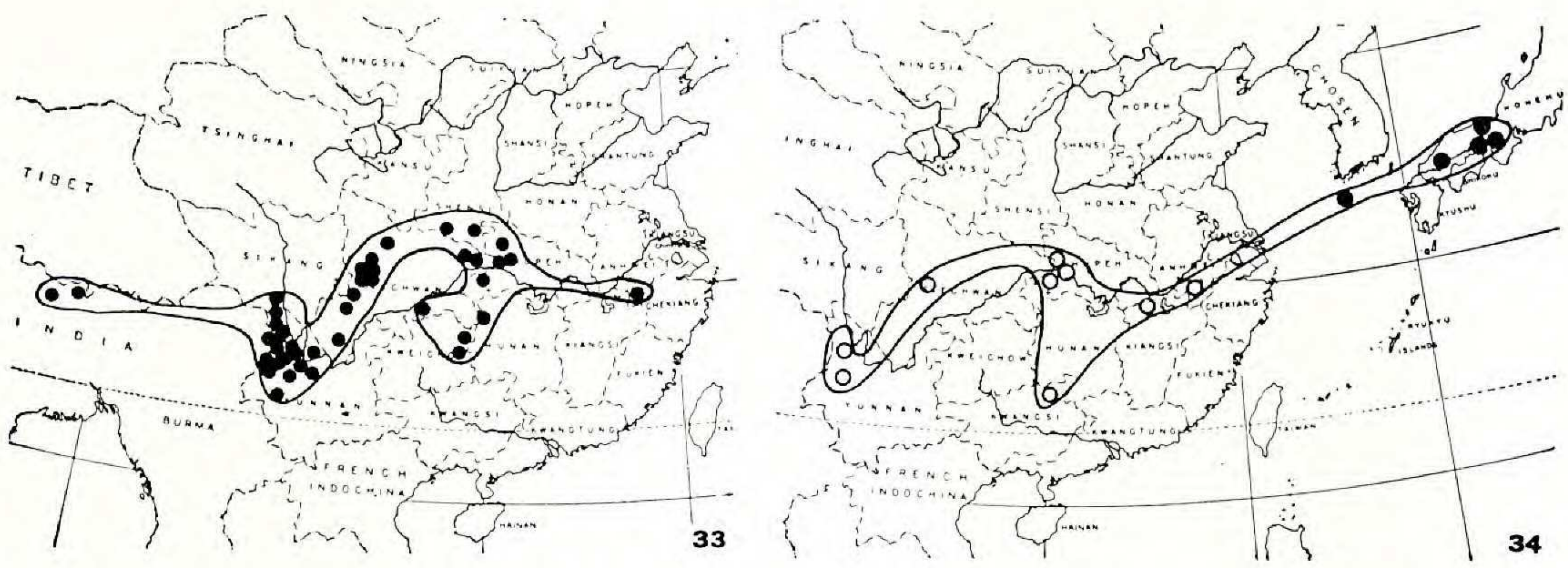
Taiwan is another area with a high degree of endemism, largely on the specific level. There are, however, a few oligotypic endemic genera which Taiwan shares with the mainland, especially with Yunnan. For example, there are 5 valid species of *Myriactis* on the mainland. These are concentrated in Yunnan and its adjacent regions, one as an endemic, one extending to Szechuan, two extending to Nepal and Kweichow. There are also one species and two varieties of the same genus in Taiwan. *Rhynchospermum verticillatum* is another species which occurs in Yunnan, Szechuan and Taiwan. There is a close tie between the flora of Yunnan and Taiwan. There are many subgeneric entities that are common to both regions and absent in areas between them. This tie is best expressed in some small endemic genera.

North China has several endemic genera of Compositae. Some of them are restricted only to one province. *Tugarinovi* and *Stilpnolepis* are known only from Suiyuan. *Takeikadzuchia* is restricted to Chahar. Others have wider ranges. *Myripnois* was first described from Peking. Additional collections have extended its range to Shansi and Kansu. *Filifolium* is known from Hopei to Heilungkiang. Probably many of these genera are due to the splitting activities of some Japanese and Russian botanists. The general flora evidently does not have a proportionate number of isolated endemics on the generic level. In general there are fewer endemics in North China. The genera characteristic of the flora of the region often extend to East China. *Xanthoceras sorbifolia* was first published from Peking. Additional collections extend its range to Shansi and Kansu. *Hemiptelea davidii* was also described from Peking but material in the herbarium of the Arnold Arboretum shows that it occurs in the Lower Yangtze Valley in the south, and in Manchuria and Korea in the north.

Northwestern China also has several endemic genera of Compositae. *Brachanthemum* is recorded from Kansu, Sinkiang and Mongolia. *Xanthopappus* from Kansu and Chinghai, *Olgaea* from Ninghsia, Shansi, Kansu, Sinkiang and Mongolia, and *Asterothamnus* is recorded from Sinkiang and Mongolia. The occurrence of these endemic genera of Compositae reflects the special character of the vegetation of the prevailing desert condition of this region. In the general flora endemic monotypic or oligotypic genera are not uncommon, especially in Caryophyllaceae, Tamaricaceae, Cruciferae and Zygophyllaceae. For example, *Acanthophyllum spinos* (Caryophyllaceae) occurs only in Sinkiang and the adjacent area of Mongolia. The monotypic genus *Tetradena* (*T. mongolica*, Zygophyllaceae), is endemic to the Kusuptschi desert of southwestern Suiyuan, and the oligotypic genus *Reaumuria* (Tamaricaceae) is represented in Kansu by *R. trigyna* and in Sinkiang and northwestern Mongolia by *R. soongorica*.

The region drained by the Middle Yangtze, that is, the Hupei-Szechuan border and the adjacent area of Shensi, marks the eastern end of Tsingling. Like the Meridional Ranges this is also a river-gorge country. But here the mountains walling the gorges of Yangtze, Hanshui and their numerous tributaries are only of moderate height. In general the river beds are about 600 ft. above sea level, and the altitudes of the mountains vary from 1800 to 7500 ft. The area is thickly populated and the vegetation is greatly disturbed. Some forests are preserved in the less accessible areas. Botanically this is the best known area of the country, for much has been published on the extensive collections made by A. Henry, E. H. Wilson, P. C. Silvestri and P. Farges from this region. In this region the endemism among Compositae is not as striking as that in the Meridional Ranges. On the generic level there is no genus which is limited to this region in particular. The genera that are endemic to China and also occur here seem to have their centers of distribution elsewhere. For example, *Ainsliaea* and *Pertya* both occur here but the center of their species concentration is evidently to the west of this area, in the Meridional Ranges. *Sheareria* also occurs here but the core of its range seems to be to the east of this area in the Lower Yangtze Valley. The endemics of this area are largely of the specific or subspecific levels, and they are relatively fewer than those of the Meridional Ranges. *Senecio doryotus*, *Ligularia fargesii*, *Ainsliaea henryi*, and *Pertya sinensis* are a few examples of the endemic species. *Ligularia hodgsonii* var. *pulchella* and *Anaphalis sinica* var. *calvescens* are some examples of the infraspecific endemics.

It seems that in this area endemism in Compositae does not reflect the picture of endemism in the general flora. It is true that this area seems to be on the periphery of the ranges of some endemic genera, for example, in the distribution of *Tetracentron sinense* (Tetracentraceae), which forms an S-shaped range over Yunnan, western Szechuan, southern Shensi and western Hupei (MAP 29). As remarked by E. H. Wilson, this monotypic genus is common in western Szechuan and rare in this area. Apparently western Hupei marks the eastern limit of the range of the genus. *Fortunearia sinensis* (Hamamelidaceae) is common in the lower Yangtze region, that is, the Anhwei-Chekiang-Kiangsu border. One collection from Chikungshan of southern Honan and one collection from Franghsien of western Hupei mark the western limit of the range of the species. *Loropetalum chinensis* (Hamamelidaceae) is widespread in the warmer region of China. It occurs in woods along the lower Yangtze valley and thence extends southward to Kwangtung and Kwangsi. Apparently its occurrence in the mid-Yangtze marks the northwestern limit of the range of this monotypic genus which is characteristic of the mesophytic forest in the warmer part of the country. On the other hand, this region constitutes the center of the ranges of some other monotypic or oligotypic endemic genera. For example, *Decaisnea fargesii* (Lardizabalaceae) and *Sinomenium acutum* (Menispermaceae) both have S-shaped distributions in Yunnan, Szechuan and Hupei. With *D. fargesii* the range extends bilaterally and with evident disjunction to Sikkim, on the west, and Huang Shan in Anhwei, on the east (MAP 33). With *S. acutum* the range extends eastward as a narrow band to Japan (MAP 34). In both genera the mid-Yangtze region is a part of the central core of their distribution. It is noteworthy that *Sinowilsonia henryi* (Hamamelidaceae) is restricted to the mountains of northwestern Hupei. *Cercidiphyllum japonicum* var. *sinense* (Cercidiphyllaceae) has an equiformal distribution from this region westward to western Szechuan and eastward to southern Anhwei. The occurrence of woody endemics in the mid-Yangtze and in the Meridional Ranges (which are sometimes called the Upper Yangtze) seems to tie the flora of the mid-high altitudes together. The relative paucity of endemics of Compositae in the mid-Yangtze region is apparently due to the absence of high mountains and alpine vegetation in the area.



MAPS 33, 34. Mid-Yangtze region as the center of two monotypic genera: 33, *Decaisnea fargesii*; 34, *Sinomenium acutum* and its variety.

The region generally called the lower Yangtze valley is another area characterized by a moderate degree of endemism. It covers northern Kiangsi, southern Anhwei, southern Kiangsu and the adjacent Chekiang. This area is a land of numerous hills. The botanically better-known ones are Lu Shan, Huang Shan, Tien-mu Shan, and the Nanking Hills, including the Ox Head Hills. Their altitudes vary from 900 to 4500 ft. The area is thickly populated and the vegetation is greatly disturbed. Endemism in the Compositae is at the specific or infraspecific level. For example, *Pertya desmocephala* is a narrow endemic which is known only from the type locality in Chekiang. *Youngia japonica* ssp. *elstonii* is known only from Chekiang and Kiangsu. At the generic level there are no Compositae limited to this area. *Sheareria* was first described from Kuling in northern Kiangsi. Additional collections extend its range to Chekiang, Hupei, Hunan and even northern Kwangtung. *Synurus* occurs in Kiangsi and Chekiang, but its range extends northward to Heilungkiang and to Japan. There are certain widespread endemic Chinese genera which are exceedingly abundant in this area. *Asteromoea, Hemistepta*, *Youngia*, and *Ixeris* are a few examples. They generally occur as weeds. Their origin is obscure and their ranges can hardly be regarded as illustrating certain distributional patterns. Endemism in the general flora of this area is more evident at the generic level than it is in the Compositae. The monotypic genera *Fortunearia* (*F. sinensis*, Hamamelidaceae) and *Fontanesia* (*F. fortunei*, Oleaceae) evidently have the center of their ranges in this area. The latter species apparently occurs more or less as a cultigen. The occurrence of several woody endemics in this area illustrates the same principle as expressed by the Composite genera. There is a close tie between the flora of this region and that of North, Central and South China. For example, *Hemiptelea davidii* (Ulmaceae) ranges from this area northward to Hopei, Shansi, Heilungkiang and Korea. The occurrence of *Decaisnea fargesii*

(Lardizabalaceae) and *Stephandra chinensis* (Rosaceae) in Huang Shan of southern Anhwei ties the flora of this area to that of Central and West China. *Fortunella hindsii* and *Ilex lohfauensis* are characteristic elements of the Wu-yi Range of southeastern China, and their northern limits are in southern Anhwei or Chekiang. The occurrence of *Cercidiphyllum japonicum* var. *sinensis* (Cercidiphyllaceae), *Sinomenium acutum* var. *cinereum* (Lardizabalaceae) in Huang Shan, Anhwei, and of *Ilex latifolia* in southern Kiangsu, Anhwei and Chekiang shows the very close relationship between the floras of this area and Japan.

The region drained by the Pearl River and its tributaries is generally known as South China. This area is a land of hills and mountains which are collectively called Nanling. The Nanling Range extends along with the tropic of Cancer from the border of Yunnan and Kwangsi eastward to the Fukien-Kiangsi-Chekiang border. The mountains are about 2000 to 4000 ft. above sea level. The vegetation is subtropical. In the last 50 years extensive botanical explorations have been made in the area largely through the coöperation of local Chinese universities and the Arnold Arboretum of Harvard University. Although much of the accumulated material awaits careful study, what has already been published is sufficient to indicate that this region possesses a relatively high degree of endemism. In the Compositae, at the generic level, there is the monotypic genus *Heteroplexis* (*H. vernonioides*) from Kwangsi. At the specific level, there are *Vernonia chingiana* from Kwangsi, *V. solanifolia* from Kwangtung, *Ainsliaea cleistogama* and *A. parvifolia* from Kwangtung, and *A. plantaginifolia* from southern Hunan. The general flora of this region shows the same pattern of endemism as reflected by the Compositae. In the north, the monotypic *Handeliodendron* (*H. bodinieri*, Sapindaceae) is restricted to the border region of Kweichow and Kwangsi. In the south, the monotypic genus *Mytilaria* (*M. laosensis*, Hamamelidaceae) is restricted to the Yunnan-Kwangsi and Indo-China border. Concentrated in this area but with wider distribution are *Bretschneidera sinensis* (Bretschneideraceae, a monotypic family) and *Eustigma oblongifolium* (Hamamelidaceae). The former species radiates in an equiformal area covering Kwangsi to northern Kwangtung on the east, eastern Yunnan on the west, southern Kweichow and Hunan in the north, and northern Indo-China in the south. The latter covers almost the same range and it extends even to Taiwan.

There are a few genera of Compositae which appear to be endemic to the flora of China as widespread weeds or as cultigens. They may be monotypic, as *Hemistepta* and *Callistephus*, or they may occur as oligotypic genera, each having one widespread variable species and a few isolated endemic species, such as *Asteromoea*, *Youngia* and *Ixeris*. This condition of endemism associated with man's activities is a common phenomenon in the general flora of China. For example, *Ginkgo* (*G. biloba*, Ginkgoaceae), *Metasequoia* (*M. glyptostroboides*, Pinaceae), *Broussonnetia* (*B. papyrifera*, Moraceae), *Platycarya* (*P. strobilacea*, Juglandaceae), *Pteroceltis* (*P. tatarinowii*, Ulmaceae), *Nandina* (*N. domestica*, Berberidaceae), *Chimonanthus* (*C. praecox*, Calycanthaceae), *Melia* (*M. azedarach*, Meliaceae), and *Ailanthus* (*A. altissima*, Simarubaceae) are all Chinese species or monotypic genera, the wild state of which is obscure, and their existence is associated with man. Probably this condition is brought about largely through man's continuous destruction of the natural vegetation. Since the period when the angiosperms became dominant features of the world's flora, there is no geological evidence that catastrophic changes have annihilated the plants of any extensive area in China as did the Pleistocene glaciers in Europe and America. Yet with the exception of the less accessible areas of the Meridional Ranges, there is hardly any area covered with natural vegetation. In most places poverty is a striking feature of the flora. Unless protected by the Buddhists as temple property, woods are rare. China is an old country, and it has long been extremely overpopulated. There has been a constantly greater demand for food than the arable land can produce. The conversion of forested areas into temporary farms by burning the hillsides is a common practice. Repeated intentional forest fires have denuded the mountains throughout the country, exterminated many species and left many others to represent isolated endemic genera or families.

In conclusion, the endemics in the Chinese Compositae reflect a very fair picture of endemism in the general flora of the country except in the mid-Yangtze region where there are proportionately more isolated woody endemics at the generic level. The lack of alpine vegetation in this area and the protection from human destruction which the steep gorges afford the vegetation of limited areas are probably the chief contributing factors of this situation.

5. Extra-Chinese Elements

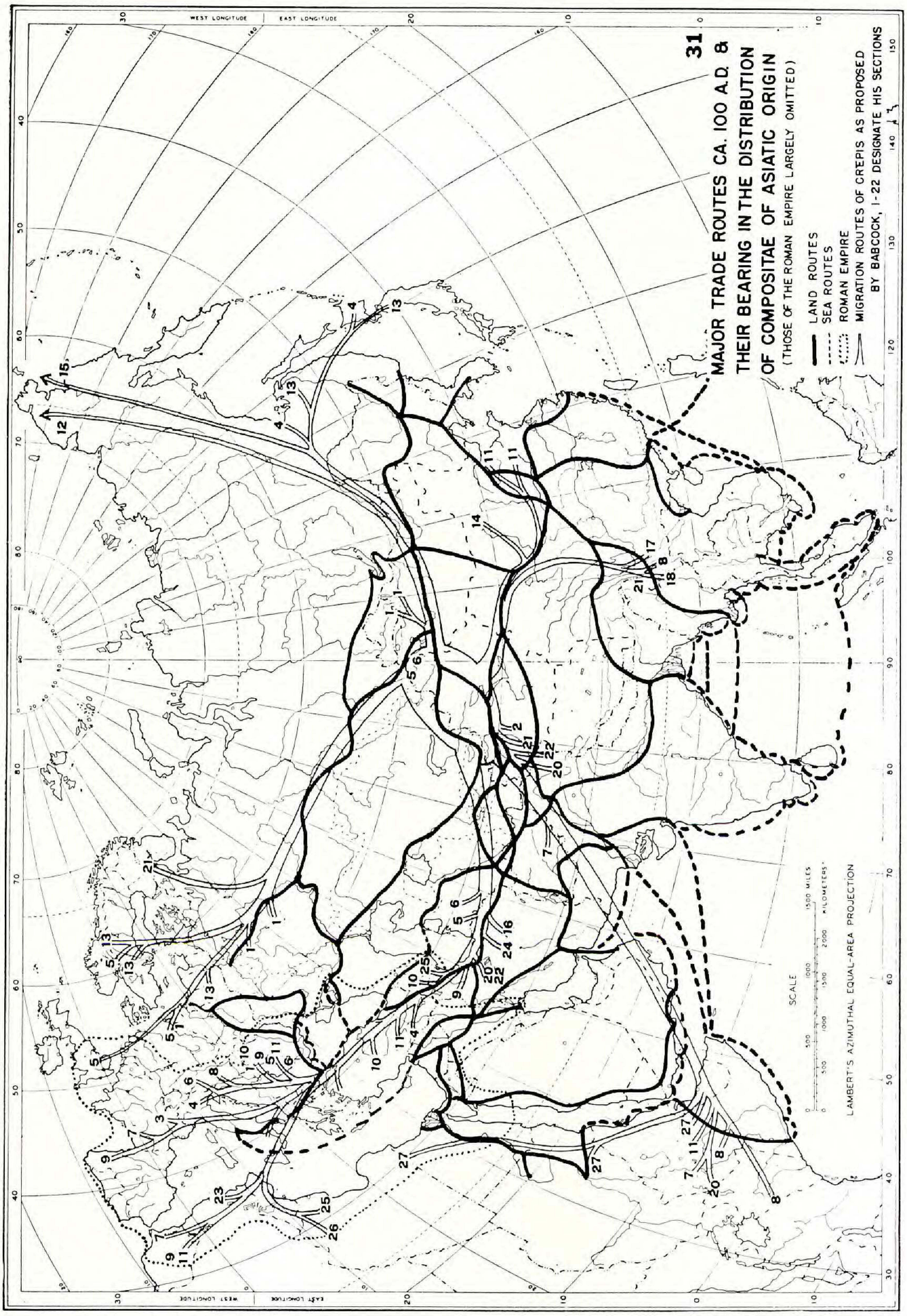
About 48% of the genera of Compositae in China are probably not of Chinese origin. Some of them have as many as 30 species, while others have only one or two or a few species. Their distribution in China is widespread either as weeds or cultigens or localized in coastal regions or port areas as adventives. In general, the tropical elements such as *Vernonia*, *Gynura*, *Blumea*, *Emilia*, *Erechtites*, etc. are concentrated in the south, especially in Yunnan, Kwangtung, Hainan and Taiwan. The Mediterranean, Central Asiatic and European elements such as *Tragopogon*, *Achillea*, *Cousinia*, *Echinops*, *Arctium*, *Matricaria*, etc. are limited to the west and the north, especially to Sinkiang, Tibet, Mongolia and Hopei. It is noteworthy that most of the widespread weeds like *Erigeron canadensis*, *Xanthium strumarium*, *Eclipta prostrata*, *Bidens pilosa*, etc. appear to be of New World origin.

As America is a melting pot of the modern world, so was China in the ancient historical times, and the flora of China is the result of this mingling. In 126 B.C. a general of the Chinese Empire subdued the people and annexed the country of the Iaxartes and Oxus rivers in Central Asia to the Han Dynasty. Since then, for approximately sixteen centuries, China has had more influence on land and sea in the Old World than most people realize. With the conquest of Central Asia began the silk trade, the most far-reaching large-scale overland commerce of the ancient time. It reached from the Pacific coast on the east to the shores of Britain on the west. Although the transactions were carried on through intermediate merchants, large-scale movement of men and animals provided the opportunity for the introduction of plants accidentally. Caravans of hundreds of horses, carts, yaks or camels passed back and forth over the great highways of Central Asia. The diary of a Taoist monk recorded that it took that 73-year-old man (Kiu Ch'ang-chung) and his 16 disciples 10 months to travel from Peking to northeastern Mongolia and thence westward to the Altai and Tien Shan mountains, and across the Pamir Plateau to reach Samarkand in 1222 A.D. (Bretschneider, 1875, p. 15–56). On their return trip it took them only three months and ten days to reach Peking through southern Mongolia, the regular postal route. The military, diplomatic, commercial and religious intercourse with Persia, India and Arabia overland (MAP 31), and through them with Europe and the Mediterranean world explain the presence of western Asiatic, Mediterranean and European elements in western and northern China.

Meanwhile, China was a sea power in the Pacific and Indian oceans for eleven centuries. There were regular communications between the mother country and the overseas Chinese in Malaysia. The commercial centers in Indo-China, Siam, India, Ceylon, Persia, Arabia and the East Coast of Africa were frequently visited by Chinese fleets (MAP 31). For example, in 1405 A.D. a fleet of 62 ships and 27,800 men, under the command of Cheng Huo went on regular patrol duties. The expedition took two and a half years. During his lifetime Cheng Huo made seven such expeditions and reached as far as Arabia and East Africa. With the periodical return of the overseas Chinese from the Malaysian islands and important ports of tropical Asia, and with the expeditions of the Chinese fleets, many tropical plants were either accidentally or intentionally introduced to the coastal regions of China. For example, *Chrysanthemum segetum* was brought in from the Arabian world to China for its edible young shoot. *Sphaeranthus africanus* has been introduced to Hainan Island and Taiwan, and a very closely related species, *S. senegalensis*, to Yunnan.

Unawareness of the interchange of plants as associated with human activities in the ancient historical times has created many unnecessary problems in plant taxonomy. *Chrysanthemum segetum* was brought in by a colony of Arabians who came to Canton about the fourth century. It has been adopted by the Cantonese as a vegetable and has spread with them to all warmer parts of China. Chinese plants in most herbaria have been named *C. coronarium*. Bailey in 1917 saw the plant in Chinese gardens and named it *C. coronarium* var. *spatiosum* in 1920. The same cultivar has been named by Loureiro as *Buphthalmum oleraceum* from Canton in 1790. Likewise, material of *Sphaeranthus africanus* from South China has been named *S. cochinchinensis* by Loureiro, *S. suberiflorus* by Hayata.

This confusion is not limited to the nomenclature of species of Compositae. It is a common disorder in the taxonomy of many Chinese plants. *Angraecum falcatum* was published from a plant supposedly of Chinese



MAP 31. The major trade routes ca. 100 A.D. and their bearing on the distribution of Compositae of Asiatic origin. (Base map Goode's No. 205.)

origin. In the last 170 years orchidologists have placed it in nine different genera and a long list of synonyms has been created on its account. In China it has only been collected from the vicinity of Ningpo in Chekiang, a center of Chinese Buddhism. There is no other Chinese orchid that is closely related to it. In the Ames Orchid Herbarium of Harvard University I found its nearest relative to be an African species, *A. pusillum*. Perhaps this isolated Chinese cultigen was one of the ancient introductions from Africa.

The migration of plants accompanying the large body of human movement is always reciprocal. There were Chinese plants introduced and established in Africa long before Linnaeus' time. *Myrsine africana* Linn. was originally described from Ethiopia. The wide distribution of the species in the interior of China and concentration of related species of the genus in eastern Asia indicate that the natural origin of *M. africana* is Chinese.

VI. THE REFLECTION OF CHINESE COMPOSITAE ON THE ORIGIN AND ROUTES OF MIGRATION OF SOME MEMBERS OF THE FAMILY

It is well known that China is one of the most unique phytogeographical regions of the world. Before the data on the Compositae of this important phytogeographical region were available, James Small had proposed a hypothetical scheme for the origin and development of the Compositae of the world. Although his scheme has been questioned and disproved by competent monographers of special groups, such as Babcock and Stebbins, it has also been followed by synantherologists who work on the entire family of certain regions, like Kitamura. Now, what advancement can a better knowledge of the Chinese Compositae offer to the understanding of the origin of and routes of migration of some genera of Compositae?

Small's long article on the Origin and Development of the Compositae was published in thirteen issues of *The New Phytologist*. His main thesis "is that *Senecio* was the first genus of the Compositae to come into existence and that it has directly or indirectly given rise to all the other genera of the family." He considered "the origin of one definite kind of living organism from another definite kind of living organism as a normal, natural result of the actual *living* of the parent organism in a particular region," and, upon many suppositions, he derived *Senecio* from the *Siphocampylus-Centropogon* group of Lobelioideae. As these genera are natives of tropical America, he proposed that *Senecio* and, in turn, Compositae originated in or about the Bolivian region of South America. He suggested further that from tropical South America the genus migrated along the Andes northward to Central America and then along the Cordilleran system to Alaska, thence to the Old World. He maintained that throughout the world the path of migration of the genus is commonly along the mountain ranges, usually about 3000 ft. and frequently above 6000 ft. To illustrate his scheme of the development of the subdivisions of the family he made the large number of species of *Senecio* to represent the substantial trunk and constructed a family tree for the Compositae, employing this to show the evolution of the principal subdivisions through certain modern genera in time and space.

Although Small's article contains informative summaries of former works on Compositae and helpful observations which advance our understanding of the family, his conclusion on the origin and development of Compositae is unsupportable. It represents too much "mental effort," in Small's own words, and little truth. First, the origin of an inclusive family like the Compositae is not so traceable as to have a living parent, as Small put it. Recent researches in smaller categories of Compositae, for example Babcock's *Crepis*, Keck's *Artemisia* and Stebbins' *Dubyaea*, *Soroseris*, etc., all indicate that present evidences are not sufficient even to trace the precise progenitors of a genus, a section or a subtribe of Compositae. No one can pretend to know the exact origin and development of the Compositae. Secondly, *Senecio* is not a primitive genus in the Compositae. It is large, inclusive and heterogenous. It is inevitable that such an artificial genus is polyphyletic. Thirdly, in constructing the family tree to show the evolution of the Compositae in time and space, a very important geobotanical region, central and eastern Asia, including China, was not included. This omission of a region which is vital in the origin, development and distribution of plants, animals, men and culture, naturally shifted the actual points of origin of many genera or even tribes of Compositae to some assumed areas.

1. On the Origin of Compositae

The origin of Compositae is obscure and it may never be elucidated. There are many gaps in the fabric of the evolution of the angiosperms. The missing progenitor of the Compositae is but one of them. Paleobotanical evidences in the Cromerian Beds in England, in the Teglian and the Reuverian Beds in central and southern Europe and in the Wilcox Beds in North America indicate that members of Compositae were widespread throughout the northern hemisphere in the Oligocene era. Fossil remains of achenes distinctly resemble those of modern species including *Tussilago farfara*, *Lapsana communis*, *Picris hieracioides*, *Crepis fuscipappus*, *Carduus nutans*, *Cnicus palustris*, *Cirsium heterophyllum*, and *Eupatorium japonicum,* indicating that members of the Senecioneae, Cichorieae, Cynareae and Astereae were common in the Old World in the Pliocene era. Evidence for a progenitor of Compositae is lacking, and the home of the origin of the family is obscure, as is that of the angiosperms. Large genera with hundreds or thousands of species, like *Senecio* and *Aster* are heterogenous. Their subgenera or sections may possibly represent taxa of entirely different origins.

2. On the Asiatic Origin of Some Widespread Genera

Babcock's classical treatment of the genus *Crepis* elucidated the origin and routes of migration of a complicated, widespread genus of Compositae.

His conclusions throw light upon our understanding of the origin and distribution of many widespread genera which have distributional patterns similar to that of *Crepis* (e.g., *Aster*, *Leontopodium*, *Artemisia*, *Chrysanthemum* including *Tanacetum*, *Senecio* including *Cacalia*, *Ligularia* and *Cremanthodium*, *Saussurea*, *Jurinea*, *Taraxacum* and *Lactuca*). These genera were formerly regarded as of European or American origin. Additional evidence favors the suggestion that they are actually of Asiatic origin. As illustrated in TABLE V, China has the largest number of species in Asia in each of these genera. In China the Meridional Ranges appear to be the center of their species concentration. One may safely conclude that Meridional Ranges are the home of these large genera of Compositae.

TABLE V. **Widespread genera with an unusually large number of species in China**

	INDO-CHINA	INDIA	CHINA	JAPAN	KOREA	PAMIR	SIBERIA
Aster	1	14	137	35	9	2	9
Leontopodium	1	1	57	6	3	1	2
Gnaphalium	3	7	20	3	4	0	4
Anaphalis	0	0	51	5	1	0	0
Carpesium	2	2	18	10	5	0	0
Artemisia	4	27	156	40	37	20	58
Chrysanthemum	2	4	73	30	10	7	3
Cacalia	0	0	60	25	7	0	1
Senecio	9	63	160	13	10	3	22
Ligularia	0	0	105	10	7	1	5
Cremanthodium	0	7	47	0	0	0	0
Saussurea	3	39	270	53	31	7	25
Jurinea	0	3	18	0	0	1	4
Ainsliaea	0	4	47	10	3	0	0
Taraxacum	0	2	57	37	2	22	2
Lactuca	9	22	57	6	4	1	7
Crepis	6	14	31	2	0	3	14
Youngia	0	0	30	6	6	0	0

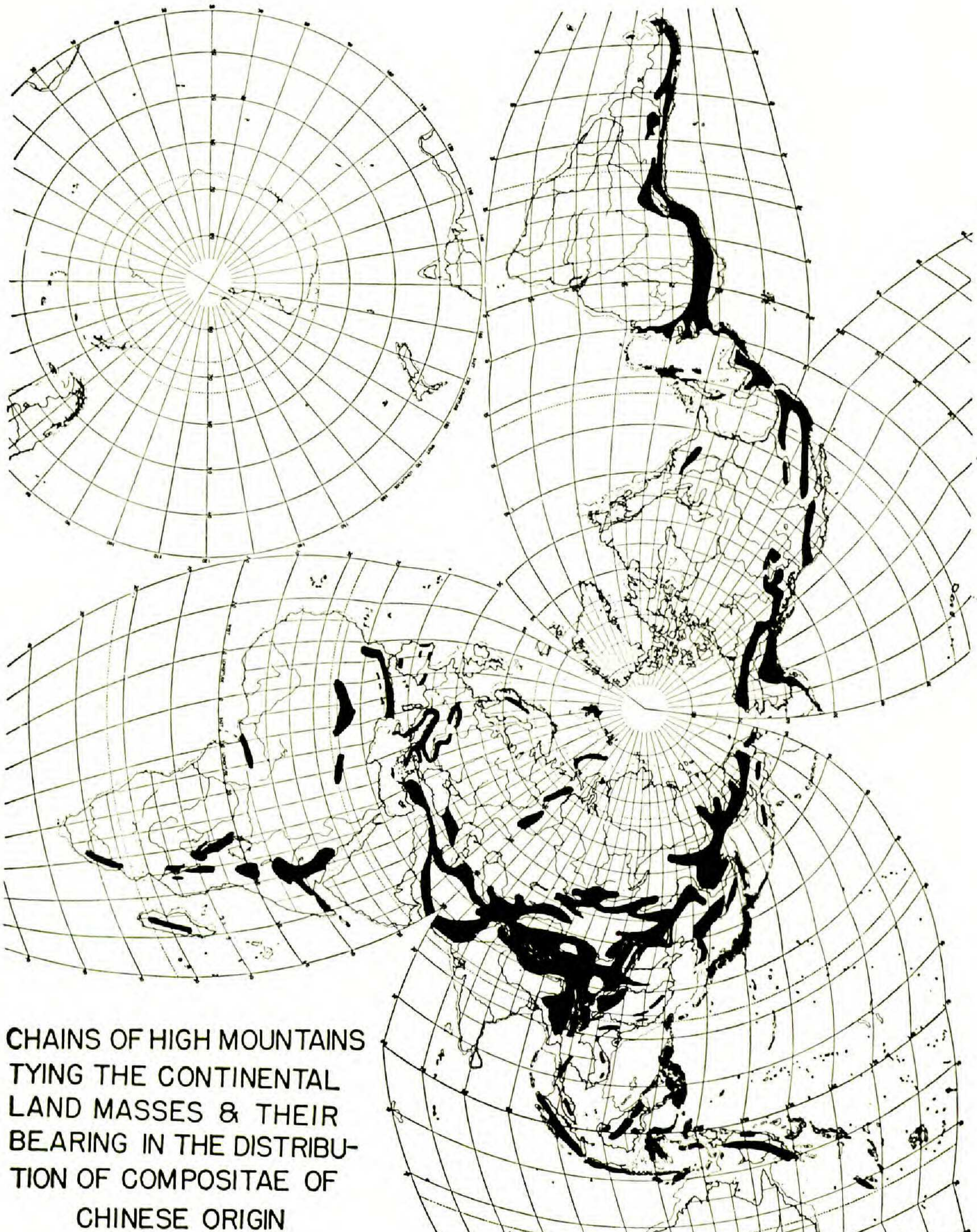
In our discussion on the area richest in Compositae we have pointed out the climatic conditions and the floristic character of the Meridional Ranges. The distribution maps of the large genera of Compositae of China, (MAPS 3, 6, 11–15, 17–19, 21–23), all indicate that these genera actually aggregate in this area. It is highly possible that the area richest in Compositae may also be the home of many of the large genera of Chinese Compositae. Geological, geographical, and floristic evidences seem to give support to this proposition.

Geological evidences seem to favor the suggestion that the Meridional Ranges are the home of montane and alpine genera such as *Leontopodium*, *Jurinea*, *Aster*, *Artemisia*, *Senecio*, *Ligularia*, *Cremanthodium*, etc. This region is geologically much older than the surrounding area. While the present Szechuan Basin and the Tibetan Plateau were still beneath the

Tethys Sea throughout the Cretaceous, rising land and mountains were already in existence in this region. Montane and alpine flora existed here before the Himalayan uplift in the late Eocene. Authorities on the flora of Tibet generally regarded the alpine elements of that region and the Himalayas as being derived from that of this river-gorge region (Ward, 1935, p. 264). Here, localized glaciation may have occurred at higher elevations, but the lower valleys, especially those nearer to the equator, have never been touched by the Pleistocene glaciers. Thus the Meridional Ranges have become a haven as well as a producer of many modern genera of angiosperms, including some Compositae.

Geographical evidences justify the consideration that the Meridional Ranges are the home of some widespread genera which occur in all important mountain ranges of the world. Map 35 represents a polar equal-area projection of the world with the continental land-masses developed radially from the north pole and the major mountain ranges plotted in black. It is worthy of note that the various continental masses are tied together by more or less continuous chains of high mountains, with the center of the tie falling in central and southeastern Asia. This phenomenon is of profound significance in the understanding of widespread genera or species of plants and animals. It is of special interest to us in our consideration of the possible origin and routes of migration of genera of Compositae of Asiatic origin. First, among all the living species of animals and plants there is one cosmopolitan species the origin of which is somewhere in this core and which is known to have immigrated gradually from here to all the major land-masses of the world in prehistoric times, without the aid of a land-bridge or continental drift. This species is *Homo sapiens*. Secondly, the Meridional Ranges are also a portion of the same core of the world's land-masses. It is highly possible that such montane and alpine genera as *Senecio*, *Aster*, *Artemisia*, *Leontopodium*, etc., have migrated throughout the world in the same direction as man did, but with better speed because of the moving forces contributed by wind, animals and, to some extent, by water, ice, landslides and other natural mechanisms of plant dispersal.

Finally, floristic evidences testify to the antiquity and prove the originality of the present flora of the Meridional Ranges and stamp the region as the home of the genera which have their species concentration there. Paleobotanical evidences indicate that the early flowering plants which became predominant during the Cretaceous period were mostly woody plants with generalized distributions. It is generally accepted that they lived for millions of years under fairly moist and rather warm conditions. The herbaceous forms represent later developments which came about with the climatic and altitudinal changes. The mesophytic forests of the middle altitudes of the Meridional Ranges and the alpine flora of the region were developed in accordance with these paleobotanical principles. The most striking fact is that the alpine flora of this region is actually situated as if it were on an island surrounded by mesophytic forest. The majority of its components are found only as fossils in other parts of the world. The earliest known angiosperm is believed to be *Homoxylon*, known through a piece of



MAP 35. Polar equal area projection of the world showing the continental land-masses tied together by more or less continuous chains of high mountains (dark), with the center of the core in central and southeastern Asia. (Base map Goode's No. 201.)

fossil wood of Jurassic origin from the Rajmahal Hills of India (Sahni, 1932, p. 4). In the mesophytic forest of the Meridional Ranges this primitive homoxylous structure reappears in *Tetracentron sinense*. In the same forest at different levels grow *Sassafras*, *Liriodendron*, *Cercidiphyllum*, *Magnolia*, *Cinnamomum*, *Machilus*, *Ailanthus*, *Cedrela*, *Dipteronia*, *Aleurites*, *Mallotus*, *Liquidambar*, *Paliurus*, *Grewia*, *Actinidia*, *Mahonia*, *Diospyros* and *Zizyphus*. All these are well-known fossil genera to botanists in other parts of the world. Together with numerous species of *Acer*, *Populus*, *Salix*, *Viburnum*, and species of Ericaceae, Menispermaceae and Coniferae, they form the mesophytic forest of the middle-high altitudes surrounding the alpine flora which is rich in Compositae. The antiquity and the originality of the flora of the Meridional Ranges is indisputable. This is true of the many Composite genera as well as of the general flora.

3. On the Migration of Compositae

The Compositae is one of the most ubiquitous families of the flowering plants. In the extent of areas covered this family is surpassed only by the Gramineae. Actually there are more genera and species in the Compositae than in the Gramineae, but unlike the latter, members of this family do not form continuous stretches and consequently they do not become so prominent in the vegetation of any area as do the Gramineae. General ubiquity is an expression of the possibility of wide dispersal of the disseminules of the members of the family. Ridley in his monumental work on the *Dispersal of Plants throughout the World* has cited many species of Compositae as his examples of dispersals by the action of wind, the force of water or ice and by the transport of animals, including fish, reptiles, insects, birds, mammals and man. There is no need to repeat his findings here. Nevertheless, there seems to be a necessity to supplement his summaries by pointing out how man's movement over the earth has accelerated the natural processes of plant dispersal, especially in connection with the migration of Compositae.

In preparing the enumeration of the Compositae of China and in trying to apply the findings of the enumeration to the advancement of a better understanding of the vegetation of China, I have referred to hundreds of articles and books. Most of them are involved in the taxonomy of the family and its subordinate groups. Some of them are reports of botanical explorations and lists of local floras. Not a few of them are on phytogeographical principles and the geography or geology of the country. This variety of literature gives me the impression that there is an evident lag on on the part of most taxonomists and many phytogeographers in giving due emphasis to the human effect on the distribution of plants. Although it is a well-known fact that man in five thousand years has altered the surface of the earth more than has Nature in five hundred million years, when phytogeographers attempt to explain the widespread or discontinuous genera they rather rely on hypotheses of land-bridges, continental drift, and nunataks, and pay no attention to what the prehistorical and historical man might have done to bring about the present picture of natural distribution. Their writings impress the reader with their belief that the world has been left to the operation of natural processes alone. They maintain that various floras have developed *in situ* and that they have not been disturbed until the arrival of the white man. They consider the plant specimens collected by the early European explorers, and described by post-Linnaean authors as indigenous to the particular area. They believe that those plants have been left there since the Tertiary time. Such a concept is incorrect.

From the standpoint of the colonization of the world by the Europeans, there is an Old World and a New World, but from the standpoint of the inhabitation of the land surface by man, the major land-masses of the world are all old. With the exception of a few islands where active volcanoes explode periodically, there is no land surface too young to have been inhabited by man. It is true that where the land-masses are connected, as in the case of Asia-Europe-Africa, man has traveled freely to and fro. It was not uncommon for people like Abraham of Ur to wander on foot with large companies of herds and herdsmen from Iraq through Jordan to Cairo and then back to get settled in Israel. Nor was it strange for a monarch such as the Queen of Sheba to travel through the tropical heat from Ethiopia to Jerusalem for a visit. In prehistorical and historical time man has traveled far and wide. Accompanying every human movement is the deliberate or accidental introduction of plants. To overcome the barrier created by large bodies of water prehistorical man made boats long before the invention of a written language. The Neolithic culture of the tribes inhabiting the Pacific Islands and of some of the Indians in the Americas seems to indicate that these land-masses have been occupied and their vegetation disturbed for from seven to ten thousand years. The migratory races and their domesticated animals carry plants far and wide. In Asia and Polynesia the origin of many of them is obscure. This type of introduction extends over a long period of time. The early stages are beyond elucidation. In regard to the distribution of Compositae, the achenes of fifteen modern species of the family have been unearthed with the Neolithic remains in Europe. This indicated that man has been associated with these species for a long time and it is inevitable that he became instrumental in their migration.

There are some botanists who have an excellent range of knowledge of plants of certain areas, but who because of their prejudice against what they call "closet botanists" have made some hasty conclusions concerning the vegetation of isolated areas. Upon finding some colonies of plants which are closely related to a geographically remote ally, they concluded that the taxon is a relict species, implicitly ruling out the possibility that it was introduced (accidentally) by man and that what they have interpreted as an ancient survivor may actually be a recent arrival. The area that appears undisturbed to a twentieth century botanist may have been visited many times by indigenous peoples and an isolated colony may be an accidental introduction. In exchanging experiences of exploration in China, an entomologist who had surveyed the Tsingling from an airplane, and caught some ants on one of the peaks, told me that the area appeared to be uninhabitable, but my association with the hunters and medicine diggers and the collectors of wild edible plants leads me to a different conclusion. It is amazing how far-reaching is the influence of the village dwellers on the vegetation of the region, and how exact is their knowledge of where certain things grow. For the reward of a couple of sewing needles a woman had walked with me into the deep wilderness of a mountain of the Meridional Ranges to show me a special kind of bamboo. For a few pennies a fifteen-year-old medicine digger led me to an apparently virgin forest of *Tsuga*, *Picea*, *Betula* and *Acer*, to collect a species of *Cimicifuga* which yields certain medicine. What appears to a city dweller as vast wilderness is to tribal people like a playground is to school children. They seem to have visited everywhere, and know exactly where to find certain things. This is true with tribal people everywhere, in Africa and America as well as in Asia. Thus what appears to be relict species may be an accidental introduction of tribal people.

It does not take long to change vegetation through man's unintentional activities. Allan in 1940 in *A Handbook of the Naturalized Flora of New Zealand* reported that in less than two and a half centuries over 1000 species of alien plants have been recorded from that country. Many of them have firmly established themselves, and have even become dominant features in the vegetation of New Zealand. On the basis of 500 well-established aliens, Allan estimated that approximately 56% of them have entered the country in seed mixtures and been further spread by sowing. About 15% were introduced through adhesion to animals. Among the common aliens which have become abundant throughout that country are these Compositae: *Arctium lappa*, *Cirsium arvense*, *C. vulgare*, *Chrysanthemum leucanthemum*, *Senecio vulgaris*, *S. jacobaea*, *Hypochoeris radicata*, *Crepis capillaris*, and *Sonchus arvensis*. If in 200 years man can unwittingly create "a new flora and a new vegetation" in a distant land, how much more could he have done in intermingling the flora of the land he has occupied for many thousands of years? The modern man has speed, whereas the prehistoric, ancient and medieval man had time.

To illustrate man's instrumentality both directly and indirectly in the distribution of some Composite genera, I redraw Babcock's diagrammatic representation of the principal migration routes of *Crepis*, and superimpose it upon a map of the ancient trade routes (MAP 31). In so doing a striking correlation between the principal routes of migration of *Crepis* and the major ancient highways is revealed. It is undeniable that the dispersal of *Crepis* is accelerated by man's activities. As the species of *Crepis* are normally of little or no economic importance to man, one may conclude that this distribution has been unintentional. It is very possible that the dispersal has been effected through the attachment of the seeds to man and his animals.

It is customarily accepted among botanists that the fruits of *Xanthium*, *Arctium*, *Bidens*, etc., which have specially modified mechanisms for adhesion, are dispersed through attachment to animals, and that the fruits of *Taraxacum*, *Artemisia*, *Crepis*, *Senecio*, etc., which are small and plumed, are specially modified for wind dispersal. Small had demonstrated by a specially designed wind dispersal apparatus that a light breeze of 1.97 m.p.h. is sufficient to carry the seed of *Taraxacum* to indefinite distances, and that a moderate breeze of 4.4 m.p.h. can transport the seed of *Leontopodium*. Few people realize, however, that the seeds of many Compositae which have small size, light weight and achenial hairs can be transported more effectively through adhesion than by wind. When man and animal travel in nature, their feet and clothes or fur are usually wet because of dew, rain or wet ground. When the momentum of the walking feet or running animal knocks against the partially disintegrated ripe head of *Saussurea, Senecio, Crepis, Taraxacum, Leontopodium, Artemisia, Lactuca,* etc., hundreds of small, light, hairy achenes naturally adhere to the wet surface of the feet of man or to the body of an animal, and are thus carried away from the parent plant. The distance may be long or short. The German botanists have attributed the migration of a Chinese species, *Lactuca tatarica*, to Europe through its adherence to a Steppenkuhn, *Syrrhaptes paradoxus* (Hegi, 1928, p. 1133, *fig. 809*). This is a widespread species in China. As man is the only species that has spread over the land surfaces of the earth in an era when there is no known continental drift or land-bridge, his effect on the migration of small-seeded species with disjunct or widespread distribution, especially those with small, light seeds like the Compositae, should be given serious consideration.

SUMMARY

1. The Compositae is the largest family of flowering plants in China. It contains 167 genera and 2027 species.

2. A large number of the genera are small. Thirty-two per cent of the 167 genera have only one species each. Twenty-two per cent contain two or three species each. This is due to the presence of large numbers of endemic genera in the interior and to the numerous introduced adventives in the border areas.

3. The Composite flora of China is characterized by an unusually large number of endemic species in the genera *Aster, Leontopodium, Anaphalis, Senecio, Ligularia, Cremanthodium, Cirsium, Saussurea, Jurinea, Ainsliaea, Taraxacum, Lactuca, Crepis, Youngia, Pertya* and *Ixeris*. Like *Dubyaea, Soroseris, Callistephus* and other local endemics, these genera should be considered to be Chinese in origin. Although some of them occur in China's neighboring countries, their numbers there are much smaller.

4. The distribution of the Chinese Compositae is very uneven. Many of them concentrate at the river-gorge area on the Yunnan-Szechuan-Sikang-Kansu borders, known also as the Meridional Ranges. The distribution of many species forms an S-shaped range over these mountains and thence extends north-eastward or westward.

5. About 48% of the Chinese Composite genera are extra-Chinese elements. Species of these genera generally are concentrated in the bordering areas. The bordering provinces in adjacent Central Asia and Siberia, that

is, Sinkiang, Mongolia, Heilungkiang and Tibet, have a considerable number of central or western Asiatic, European or Mediterranean genera such as *Echinops, Carduus, Achillea,* etc. Their distributions seldom extend south to the Yangtze River. The Composite flora of the coastal provinces, namely, Kwangtung, Fukien, Taiwan and Hainan contains a considerable number of pantropic elements such as *Blumea*, *Vernonia*, *Elephantopus*, *Sphaeranthus*, *Spilanthus*, etc. The distribution of these genera seldom extends north of the Yangtze River.

6. The immigration and emigration of Composite genera in and out of China correlate fairly well with the ancient trade routes and modern waterways. Evidently the distribution of many widespread genera as well as some localized adventives are associated with man's activities. The more widespread genera have had longer periods of association with man and the localized adventives are recent arrivals.

7. The origin of the Compositae is obscure. The Meridional Ranges of China constitute an area of origin of widespread large genera as well as of small narrow-endemic ones. Geologic, geographic and floristic evidence all favor this conclusion.

8. The degree of endemism is relatively high in Chinese Compositae. About 30% of the genera are endemic. There is no regional limit of endemism at the species level. The endemic genera are concentrated largely in the Meridional Ranges.

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